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Automobile Assembly Plant Spray Booth Cleaning Emission Reduction Technology Review

control technology center

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AUTOMOBILE ASSEMBLY PLANT SPRAY BOOTH CLEANING EMISSION REDUCTION TECHNOLOGY REVIEW

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Spray Booth Cleaning Emission Reduction Technology Review Automobile Assembly Plant

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PREFACE

The Automobile Spray Booth Cleaning Technology investigation was funded as a project of EPA's Control Technology Center (CTC).

The CTC was established by EPA's Office of Research and Development (ORD) and Office of Air Quality Planning and Standards (OAQPS) to provide technical assistance to State and local air pollution control agencies. Three levels of assistance can be accessed through the CTC. First, a CTC HOTLINE has been established to provide telephone assistance on matters relating to air pollution control technology. Second, more indepth engineering assistance can be provided when appropriate. Third, the CTC can provide technical guidance through publication of technical guidance documents, development of personal computer software, and presentation of workshops on control technology matters.

The technical guidance projects, such as this one, focus on topics of national or regional interest that are identified through contact with State and local agencies. This study was requested by the State of Michigan. It provides technical information that will help agencies develop strategies for reducing VOC emissions from cleaning automobile spray booths.

This report provides information on the spray booth cleaning process and alternative cleaning practices that reduce or eliminate the use of organic cleaning solvents. It provides a ready reference to actions reported by eight automobile companies to reduce emissions from booth cleaning operations. It is carefully referenced to allow readers to take advantage of others' work. A summary of the cleaning practices currently being used by 15 automobile assembly plants is included, as is each plant's VOC emissions from spray booth cleaning. Additionally, a summary of the alternative cleaning practices identified for each major component of the booth is presented, and the non-VOC cleaning practices are identified. The Unit Operation System (UOS) material balance approach was used to calculate VOC emissions from cleaning spray booths.

ACKNOWLEDGEMENT

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The cooperation of numerous personnel in the automotive assembly industry is greatly appreciated; without their assistance in providing information and answering questions this report could not have been prepared.

Mr. Eugene A. Praschan, American Automobile Manufacturers Association; Mr. Marvin Floer, Chrysler Corporation; Ms. Sharon D. Dudzinski, Chrysler Corporation; Mr. John E. Davidson, Ford Motor Company; Ms. Christine Bates, General Motors Corporation; and Ms. Karen Heyob, Honda of America Manufacturing, are especially acknowledged for their efforts in arranging site visits to facilities and for coordinating the information-gathering activities for their respective corporations. Numerous personnel at each of the plants responded to the information requests from the Agency and provided followup information when requested; their cooperation is greatly appreciated.

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1.0 INTRODUCTION

This study, requested by the State of Michigan, attempted to identify reasonable alternatives for minimizing Volatile Organic Compound (VOC) emissions during cleaning of paint residue from automobile assembly paint spray booths. This section presents the background, objectives, and technical approach of the study. The organization of the remainder of the report also is presented.

1.1 BACKGROUND

When vehicles are being painted in the automotive industry, some of the paint material sprayed in a booth lands on the walls, windows, robots, fixtures, floor grates, and other components of the spray booth rather than on the vehicle being painted within the booth. Since the primer, surfacer, and topcoat paints used by the industry cure only when heated, this "paint overspray" creates a sticky residue. The large quantities of sticky residue generated during painting result in the need to clean the paint spray booth on a regular basis. The ratio of the amount of paint material deposited on the automobile to the amount sprayed is called the transfer efficiency. As the transfer efficiency increases, more paint material adheres to and leave the booth on the automobile, and a lessor fraction of the paint material sprayed becomes paint residue that adheres to the booth components.

The industry uses extensive cleaning procedures to clean paint spray booths. Traditionally, paint spray booths in the automotive industry were cleaned with organic solvents. Solvents containing organic compounds readily dissolve the paint overspray, but evaporation of organic solvents during cleaning also results in VOC emissions. State agencies have been aware that some auto assembly plants (both existing and new) have been successful in reducing VOC emissions from booth cleaning. However, details of the "cleaning practices" that reduce or eliminate the use of organic solvents and, consequently, reduce VOC emissions from spray booth cleaning, have not been made generally available. Furthermore, because emissions resulting from spray booth cleaning typically have been quantified based upon "engineering judgment" estimates of solvent usage, rather than on a systematic approach using actual data (e.g., usage records), accurate and reliable information on nationwide VOC emissions from this source has not been available.

1.2 OBJECTIVES

The overall objective of this study is to report technical information on the available alternative cleaning practices that reduce VOC emissions from cleaning spray booths. Within this overall objective were two specific objectives. The first specific objective was to document the use of alternative cleaning practices identified, if any, and evaluate the reduction in VOC emissions achieved. The second specific objective was to document and explain procedures for estimating VOC emissions from spray booth cleaning. By meeting these objectives, this report provides technical information that will help agencies develop strategies for reducing VOC emissions from automobile booth cleaning. A summary of the cleaning practices currently being used by 15 automobile assembly plants is included; specific cases are noted where reductions in VOC emissions resulting from the use of alternative cleaning practices have been documented. A systematic scheme for quantifying VOC emissions from cleaning spray booths is presented and discussed.

1.3 TECHNICAL APPROACH

The technical approach used for the study involved obtaining, evaluating, summarizing, and documenting specific information on alternative cleaning practices being used by industry. State agencies were contacted via telephone to obtain relevant information based upon their experiences with permitting or setting standards for VOC emissions from this source. Vendors were contacted to obtain information on available cleaning compounds and other cleaning materials or equipment that eliminates or reduces the need for organic cleaning solvents. Automobile and light-duty truck manufacturers were contacted to obtain information on cleaning practices used in their auto assembly plants. Plants with diverse characteristics were selected for information-gathering purposes. General plant information was obtained from industry associations and telephone calls to some of the facilities. In determining which plants would receive a survey, various factors were considered, including the age of the plant, the age and type of the paint shop (with modular or main-color split booths), the size of the product (compact cars, mid-size cars, full-size cars, and light-duty trucks), the type of paint applied, and the use of alternative "cleaning practices."

The information from auto manufacturers was collected systematically using questionnaires and plant visits under the authority of Section 114 of the Clean Air Act. The following types of information were solicited: (1) the design of the paint shops, types of paint spray booths, and the painting process; (2) the cleaning requirements and specifications; (3) the use of organic cleaning solvents and the use of alternative cleaning practices to reduce organic cleaning solvent usage; (4) the amount of VOC emissions from spray booth cleaning calculated using a Unit Operation System[1,2] (UOS) (to ensure reporting of emissions on a consistent basis); (5) details on the applicability, effectiveness, and costs of alternative cleaning practices and cleaners used by the facility; and (6) the VOC reductions achieved through the use of specific alternative cleaning practices.

This report is primarily based on the information collected from 15 plants, operated by 8 companies. The location, the number of work shifts per day, the total number of hours worked per year, the model of cars produced, the production rate, and the number of employees for each of the 15 plants are presented in Appendix A. Throughout the rest of this report, any reference to "all plants" or "plants" alludes to these 15 car or light-duty truck assembly plants.

1.4 REPORT ORGANIZATION

The remainder of this report is divided into six sections. Section 2 presents a summary of the study results, conclusions, and recommendations for further study. Section 3 presents an overview of the automotive industry and automotive painting process. Section 4 identifies spray booth components requiring cleaning, and describes cleaning techniques. Section 5 presents the UOS methodology used for systematically calculating VOC emissions and an example calculation. Section 6 presents a summary of the ways in which solvent was used for cleaning in the surveyed plants and the resultant VOC emissions. Section 7 describes the types of alternative cleaning practices used at the surveyed plants in 1991; the advantages, limitations, solvent usage and VOC reductions reported are presented and discussed.

Appendix A presents a summary of the information provided by the 15 plants, including the number of vehicles produced, the number and types of spray booths, use of cleaning solvents, and booth emissions. Appendix B provides a detailed profile of each facility describing the spray booths, types of paint, cleaning practices, use and disposal of booth cleaners and purge solvents, and VOC emissions. Appendix C presents a list of definitions for terms common to industrial cleaning activities.

1.5 REFERENCES FOR SECTION 1

1. Memorandum from Wyatts, S ., EPA, to "Industrial Cleaning Solvents - ACT" project file. February 24, 1994. "Unit Operation System" - Originator of Concept.

2 Serageldin, M.A., "The Unit Operation System--A New Solvent Management System;" U. S. Environmental Protection Agency APTI Course No. 582: Issues Related to VOC Control Systems Teleconference Workshop. July 22-23, 1993.

2.0 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

2.1 SUMMARY

In the past, practices heavily relying on the use of solvents were used to remove paint overspray during cleaning of spray booths. Organic solvents containing VOC's readily dissolve paint overspray, but their use results in VOC emissions. Alternative practices which reduce or eliminate cleaning solvents will reduce VOC emissions. This study was conducted to obtain and evaluate information on: (1) the use of alternative "cleaning practices" within the industry, (2) the level of VOC emissions resulting from spray booth "cleaning activities," and (3) the emission reductions achieved by implementing alternative cleaning practices.

During the study, information submitted by 15 plants as the result of plant visits and an information request (under the authority of Section 114 of the Clean Air Act Amendments of 1990) was reviewed, evaluated, and summarized. Table 2-1 shows where solvent was used at these plants and the cleaning activities associated with its use. Uses were identified for seven categories of booth components. While Table 2-1 does not show the amount of solvent used for cleaning each type of component (and this information was rarely available), it does show that two or more plants did not use solvent to clean five components. It also shows solvent was used for at least some cleaning of spray equipment tips and robots and related equipment at each plant.

Table 2-2a and 2-2b and Figure 2-1 reveal wide variation in spray booth cleaning solvent usage and VOC emissions. For comparison among facilities, the annual emissions were normalized

TABLE 2-1. SOLVENT USES FOR BOOTH COMPONENTS AT SURVEYED PLANTS

Plant\component	Walls	Floors	Grates	Robots/ equipment	Spray equip- ment tips	Windows	Fixtures	Ref.
AutoAlliance	Wipe/scrub			Wipe	Wipe/dip	Scrub		1
Chrysler (Belvidere)		Mop		Wipe	Wipe		Spray[a]	2
Chrysler (Dodge City)	Spray	Mop		Wipe	Wipe	Spray		3
Chrysler (Sterling Heights)	Wipe			Wipe	Wipe	Scrub		4
Ford (Chicago)	Scrub[a]			Spray	Dip	Scrub[a]	Scrub[a]	5
Ford (Dearborn)		Mop		Wipe	Wipe			6
Ford (Twin Cities)	Spray/scrub	Mop		Wipe/dip	Dip/scrub	Spray		7
GM (Fort Wayne)	Spray		Spray	Wipe	Wipe	Spray		8
GM (Moraine)	Spray		Wipe	Spray/wipe	Spray/wipe	Spray		9
GM (Oklahoma City)		Mop		Spray/wipe	Dip/wipe	Wipe	Wipe/spray	10
Honda (East Liberty)	Wipe	Wipe		Wipe	Wipe	Wipe		11
Honda (Marysville)	Wipe			Wipe	Wipe	Wipe		12
Nissan	Wipe	Wipe/mop[a]		Wipe	Wipe	Wipe	Wipe	13
Subaru-Isuzu				Wipe	Dip	Wipe		14
Toyota	Wipe		Dip	Wipe	Wipe	Wipe/spray	Wipe	15

[a]Low VOC cleaner.

TABLE 2-2a. PRODUCTION, SOLVENT, AND EMISSION DATA FOR SURVEYED PLANTS IN 1991 (English Units)

Plant	Ref.	Vehicles produced	Booth cleaning solvent usage, gal/yr	Booth cleaning VOC emissions, tons/yr[a]	Normalized booth cleaning VOC emissions, tons/yr at 500 shifts/yr[b]
AutoAlliance	1	167,900	14,600	45	45
Chrysler (Belvidere)	2	178,087	47,447	160	211
Chrysler (Dodge City)	3	177,134	66,525	228	265
Chrsyler (Sterling Heights)	4	137,842	25,656	86	139
Ford (Chicago)	5	218,328	99,502	347	413
Ford (Dearborn)	6	81,563	5,278	14	26
Ford (Twin Cities)	7	125,275	98,139[c]	78[d]	100
GM (Fort Wayne)	8	178,520	53,086	193	239
GM (Moraine)	9	228,925	>189,517[e]	>657[f]	>730
GM (Oklahoma City)	10	170,501	97,696[g]	251	285
Honda (East Liberty)	11	94,222	31,807	114	114
Honda (Marysville)	12	356,967	184,400	671	671
Nissan	13	262,000	41,934	146	152
Subaru-Isuzu	14	116,297	10,250	35	36
Toyota	15	187,951	282,289	940	979

[a]Actual emissions reported for 1991 shifts operated.
[b]Actual emissions reported for 1991 normalized to 500 operating shifts/yr.
[c]The plant collected some spent solvent from booth cleaning practices, but the amount was not reported.
[d]This value was reported by the plant, but it is not clear how it was determined. Unresolved discrepancies in the data are described in Section 6.
[e]This value could be higher by up to 9,929 gal/yr.
[f]This value was calculated based on usage data; the plant reported different emissions, as noted in Section 6.
[g]Collected spent solvent contained about 25 percent of the solvent used for booth cleaning.

TABLE 2-2b. PRODUCTION, SOLVENT, AND EMISSION DATA FOR SURVEYED PLANTS IN 1991 (Metric Units)

Plant	Ref.	Vehicles produced	Booth cleaning solvent usage, l/yr	Booth cleaning VOC emissions, Mg/yr[a]	Normalized booth cleaning VOC emissions, Mg/yr at 500 shifts/yr[b]
AutoAlliance	1	167,900	55,300	41	41
Chrysler (Belvidere)	2	178,087	179,600	145	191
Chrysler (Dodge City)	3	177,134	251,830	207	241
Chrsyler (Sterling Heights)	4	137,842	97,120	78	126
Ford (Chicago)	5	218,328	376,660	315	375
Ford (Dearborn)	6	81,563	19,980	13	24
Ford (Twin Cities)	7	125,275	371,500[c]	71[d]	91
GM (Fort Wayne)	8	178,520	200,950	175	217
GM (Moraine)	9	228,925	>717,400[e]	>597[f]	663
GM (Oklahoma City)	10	170,501	369,820[g]	228	259
Honda (East Liberty)	11	94,222	120,400	104	104
Honda (Marysville)	12	356,967	698,000	609	609
Nissan	13	262,000	158,740	133	138
Subaru-Isuzu	14	116,297	38,800	32	32
Toyota	15	187,951	1,068,590	850	889

[a]Actual emissions reported for 1991 shifts operated.
[b]Actual emissions reported for 1991 normalized to 500 operating shifts/yr.
[c]The plant collected some spent solvent from booth cleaning practices, but the amount was not reported.
[d]This value was reported by the plant, but it is not clear how it was determined. Unresolved discrepancies in the data are described in Section 6.
[e]This value could be higher by up to 37,590 l/yr.
[f]This value was calculated based on usage data; the plant reported different emissions, as noted in Section 6.
[g]Collected spent solvent contained about 25 percent of the solvent used for booth cleaning.

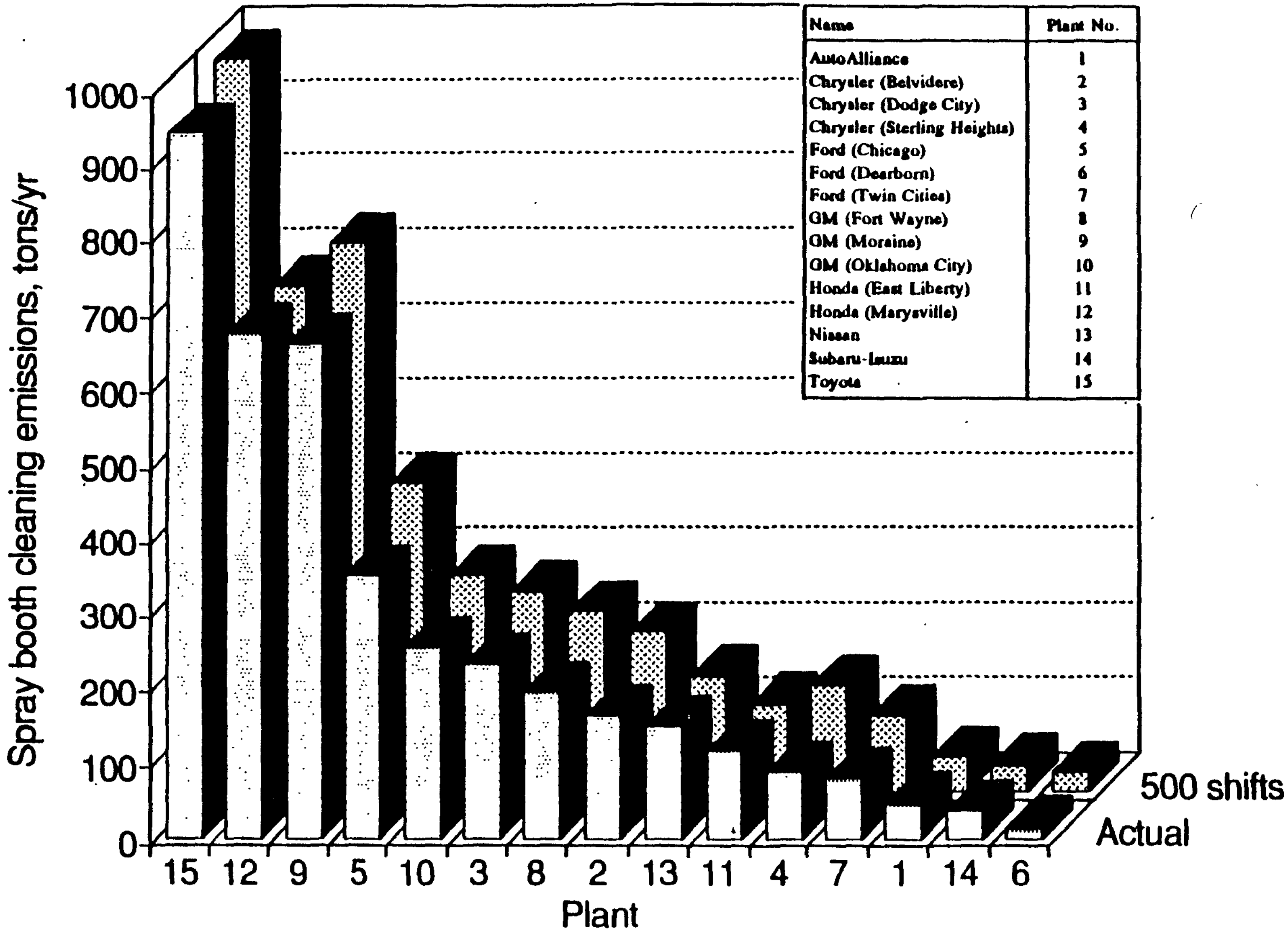

Figure 2-1. Comparison of reported 1991 emissions from spray booth cleaning with emissions normalized to 500 operating shifts.

to a basis of 500 operating shifts (not cleaning shifts). The number of operating shifts was selected as a normalizing parameter because each plant reported operating 2 shifts per day, 5 days per week, and about 8 hours per shift; however, the number of weeks of operation ranged from 27 to 50. Also, most cleaning was performed weekly (or more frequently); solvent usage and VOC emissions should be directly proportional to the number of operating weeks (or the corresponding number of operating shifts). Five hundred operating shifts (2 shifts/day x 5 days/week x 50 week/year) was selected as the normalizing factor. Tables 2-2 and Figure 2-1 present the normalized emissions.

All plants used one or more alternative cleaning practice. Table 2-3 presents the alternatives that the survey revealed were being used for the various booth components. The alternatives have been separated into three groups. The first group (Column 2) contains alternatives (listed in decreasing order of prevalence) that eliminated solvent usage and associated VOC emissions. The second and third groups (third and fourth columns) present alternatives with progressively less potential to reduce VOC emissions. Alternatives in the second and third groups should be considered if design features or other technological or economic limitations preclude the use of any of the alternatives in the first group.

The distribution between the second and third groupings is subjective; the amount of reduction achieved will, to some extent, depend on how the alternative is applied. For example, the frequency with which solvent is used to wipe down peelable coatings on walls will determine the degree of emission reduction that can be achieved. In developing the group with high potential to reduce emissions (Column 3), it was assumed that solvent would be used sparingly.

Table 2-4 shows the alternative cleaning practices for each booth component that resulted in the highest reported reductions. The two largest reductions resulted from implementing alternatives that eliminated spraying of solvent on walls and

TABLE 2-3. RANKING OF ALTERNATIVES FOR CLEANING EACH BOOTH COMPONENT

Booth component	Alternatives that totally eliminate VOC emissions[a]	Alternatives that reduce VOC emissions	
		More likely to result in low emissions	Less likely to result in low emissions
Walls (main coating booths)	-- Peelable coating -- Tacky coating removed by water blasting -- Plastic sheeting -- Wipe with water-soaked rags[b]	-- Tacky coating removed by mixture of water and low VOC cleaner -- Peelable coatings, tacky coatings, and covers wiped with solvent occasionally -- Tacky coatings removed by water blasting and spraying solvent on stubborn spots	-- Apply solvent and scrub with a brush dipped in a bucket of solvent -- Spray solvent high on the wall followed by scrubbing lower areas -- Use nonatomizing solvent spray guns -- Use a more viscous solvent in solvent spray guns
Walls (auxiliary booths)	-- Plastic sheeting -- Peelcoat -- Water blasting -- Tacky coating removed with high pressure steam -- Various papers -- Wipe with dry rags[c] -- Scrape -- Wipe with water-soaked rags -- Mask with vaseline and remove by scraping	-- Plastic sheeting or aluminum foil on part of the wall; wipe uncovered areas with solvent -- Plastic sheeting; wipe plastic with solvent occasionally	-- Apply solvent from squeeze bottle to rag instead of to wall
Grates	-- High-pressure water blasting (with or without tacky coating) -- Caustic soda bath -- Incineration	-- Caustic soda bath containing a low VOC cleaner -- Touch up cleaning (wiping)	-- Use tacky coating; remove by water blasting and solvent spray on stubborn spots
Floors	-- Tar paper -- Plastic -- Fire-proof paper-backed foil -- Chipboard -- Cardboard -- Kraft paper -- Non-VOC cleaner -- Carpeting saturated with soapy water -- Scraping	-- Use shoe cleaner to reduce trackout -- Change shoes when entering and leaving booths -- Spot clean with solvent followed by mopping with non-VOC cleaner -- Mop with low VOC cleaner -- Cover some areas and mop uncovered areas with solvent	-- Wipe with rag and solvent -- Use mechanized scrubber with solvent for open areas

TABLE 2-3. (continued)

Booth component	Alternatives that totally eliminate VOC emissions[a]	Alternatives that reduce VOC emissions	
		More likely to result in low emissions	Less likely to result in low emissions
Robots/equipment	-- Robot covers[e] -- Covers on part of equipment and wiping uncovered areas with water-soaked rags[b] -- Dry rags[c] -- Water[f]	-- Covers on part of the equipment and wiping uncovered areas with solvent -- Tacky coating on part of the cabinetry -- Plastic sheeting on some cabinetry -- Grease on some surfaces that are cleaned by scraping -- Hot water blasting and wiping with solvent[g]	-- Wiping with solvent instead of spraying
Spray equipment tips	-- Wiping with water-soaked rags[h] -- Replacement[i]	-- Ultrasonic parts cleaner -- Dip in solvent containers	-- Wiping with solvent instead of spraying
Windows	-- Wipe with non-VOC cleaner -- Scrape with razor blade or other tool -- Mask with a tacky coating that is removed with water -- High-pressure water blasting followed by wiping with a non-VOC cleaner -- Cover with plastic cling film -- Wipe with water-soaked rag[b] -- High-pressure steam -- Hot water blasting[g] -- Wipe with dry rags[c]	-- Wipe with a low VOC cleaner -- High-pressure water blasting followed by spraying solvent on stubborn spots	-- Reduce frequency of cleaning from daily to twice a week -- Switch from spraying solvent on the window (from squeeze bottle) to spraying on rags used to wipe the window

TABLE 2-3. (continued)

Booth component	Alternatives that totally eliminate VOC emissions[a]	Alternatives that reduce VOC emissions	
		More likely to result in low emissions	Less likely to result in low emissions
Fixtures	-- Various Tyvek™, plastic, and aluminum foil covers on unspecified fixtures -- Water blasting for car body carriers -- Grease and scrape center track drive covers -- Use tacky coating on center track drive covers and remove by scraping -- Scrape exhaust fan and stack -- Grease stack to improve effectiveness of water blasting -- Masking tape, grease, aluminum foil, and water blasting to clean conveyors -- High pressure water and hot water to clean various lights	-- "Flood" center track drive covers with low VOC cleaner, scrape, and flush with water	-- Wipe with rags and solvent instead of spraying
General[j]	None	-- Track solvent use -- Restrict access to solvents	-- Train operators in cleaning procedures -- Collect spent solvents -- Reduce frequency of cleaning from once a week to once every 2 weeks

[a]Listed based on frequency of use at surveyed plants.
[b]Only used in basecoat booth at a plant using a waterborne basecoat paint.
[c]Only used in sealer and deadener booths.
[d]Only for final touchup (probably because a waterborne basecoat was used).
[e]One plant used covers to avoid solvent use in main coating booths; several plants used covers to eliminate solvent use in various auxiliary booths.
[f]Used in an engine primer painting spray booth.
[g]Used in a wax application spray booth.
[h]Used on tips for applying enamel paint to fuel tanks and for applying waterborne basecoat in a repair booth.
[i]Used in booths for applying antichip coating to fuel tanks and primer to engines.
[j]The alternatives listed are work practice changes that affect the amount of solvent used for cleaning multiple booth components.

TABLE 2-4. ALTERNATIVES FOR EACH BOOTH COMPONENT THAT RESULTED IN THE HIGHEST REPORTED REDUCTIONS

Booth component	Alternative cleaning practice	Previous cleaning practice	Booths in which alternative was used	Solvent usage reduction, gal/yr (l/yr)	Emission reduction		Ref.
					tons/yr (mg/yr)	Percent	
Walls	Use viscous solvent and nonatomizing spray gun	Spray solvent with air atomizing gun	Stoneguard/topcoat (2) Topcoat Topcoat repair (3)	55,000 (210,000)	187 (170)	N/A	3
Grates	High-pressure water blasting	Incineration[a]	Stoneguard Primer Enamel (2) Tutone	2,450 (9,270)	7.9 (7.2)	100	1
Floors	Use custom-made shoe cleaner to reduce trackout from booths	Additional solvent	Topcoat Topcoat repair	4,230 (16,000)	15 (14)	N/A	7
Robots/equipment	Cover reciprocators with aluminum foil	None[b]	Antichip Topcoat (2)	8,295 (31,400)	28.6 (25.9)	N/A	4
Spray equipment tips	Deionized water	N/A	Basecoat repair	N/A	N/A	100	11
Windows	Cover with plastic cling film	Solvent[c]	Topcoat (2)	6,040 (22,900)	20 (18)	100	4
Fixtures	"Flood" center track drive cover with a lower VOC solvent; scrape residue off after 15 to 20 minutes	Spray center track drive cover with solvent	Color (2) Reprocessing	37,353 (141,400)	127 (115)	N/A	2

[a]Incineration was previously used to clean the grates, but the reductions are estimates of the amount of solvent that would be needed if no alternative were used.

[b]The plant has used the alternative since startup. The reduction is an estimate of the additional solvent that would be needed if the reciprocators were not covered.

[c]The plant did not report the application procedure.

fixtures. Although no plant reported data for eliminating spraying of solvent on robots and related equipment, it is likely that an alternative practice would also result in large reductions. Targeting alternatives for cleaning these three booth components (walls, fixtures, and robots and related equipment) is likely to achieve the largest VOC emission reductions, especially at plants that have high emissions.

Of course, the most effective way to reduce the amount of solvent needed for cleaning is to minimize overspray; if overspray is not deposited in the booth, cleaning needs are minimized. Improvements to and quality control of transfer efficiency in a plant can reduce booth cleaning needs (pollution prevention). Improvements to transfer efficiency can have multiple benefits, including reduced material costs (paint and cleaning solvents), reduced quantities of waste (e.g., sludge), and lower air pollution.

2.2 CONCLUSIONS

1. Significant potential for VOC emissions reduction exists because at least one plant cleaned each type of booth component (except spray equipment tips and some robot surfaces) without using solvent.

2. The potential for reduction depends on booth design, type of paint, and the article being painted, as well as the cleaning practices. Without analysis of these factors, the potential reduction for a particular alternative or the total reduction for the spray booths in a plant cannot be quantified. The potential reductions, however, range from a few tons to nearly 1,000 tons per year (yr) per plant, as exemplified by Figure 2-1.

3. Typically, emissions reductions achieved by specific alternatives are less than 20 tons/yr (18 megagrams/yr [Mg/yr]), but can range up to nearly 200 tons/yr (180 Mg/yr).

4. Elimination of solvent spraying, as a cleaning practice holds the greatest potential for reducing emissions.

5. The UOS concept provides a means for calculating emissions based upon solvent usage and spent solvent collection

records; the UOS allows all emissions to be calculated systematically and consistently. The key to its usefulness is getting good "source" specific data on solvent usage and collected spent solvent; the "source" being the spray booth. Knowledge of the relative fractions of solvent and contaminants contained in the spent solvent also is necessary for material balance closure. The UOS provides an ideal level for evaluating the benefits and cost-effectiveness of pollution prevention practices aimed at reducing emissions from booth cleaning.

2.3 RECOMMENDATIONS

Recommendations for possible further study include:

1. Several facilities indicated they are implementing waste reduction studies/programs. Much useful information could be obtained if facilities were to use the UOS approach for gathering data from before and after implementation of alternative practices. Collaborative studies between industry and agencies would be the best way to identify study sites and collect data.

2. Establish a data base "clearinghouse" to record the emissions and reductions achieved by specific spray booth cleaning practices. This clearinghouse would build on the reductions reported by this study as summarized in Section 7.

3. Information on the cost of implementing alternative cleaning practices was reported by some plants; these data should be summarized and evaluated to provide additional information to the agencies and facilities.

2.4 REFERENCES FOR SECTION 2

1. Response to Section 114 Information Request for AutoAlliance International, Inc., Flat Rock, MI. August 21, 1992.

2. Response to Section 114 Information Request for Chrysler Corporation, Belvidere, IL. August 1, 1992.

3. Response to Section 114 Information Request for Chrysler Corporation, Dodge City, MI. August 14, 1992.

4. Response to Section 114 Information Request for Chrysler Corporation, Sterling Heights, MI. August 14, 1992.

5. Response to Section 114 Information Request for Ford Motor Company, Chicago, IL. August 14, 1992.

6. Response to Section 114 Information Request for Ford Motor Company, Dearborn, MI. August 17, 1992.

7. Response to Section 114 Information Request for Ford Motor Company, Twin Cities, MN. August 17, 1992.

8. Response to Section 114 Information Request for General Motors Corporation, Fort Wayne, IN. August 14, 1992.

9. Response to Section 114 Information Request for General Motors Corporation, Moraine, OH. August 14, 1992.

10. Response to Section 114 Information Request for General Motors Corporation, Oklahoma City, OK. August 14, 1993.

11. Response to Section 114 Information Request for Honda of America Manufacturing, Inc., East Liberty, OH. August 12, 1992.

12. Response to Section 114 Information Request for Honda of America Manufacturing, Inc., Marysville, OH. October 29, 1992.

13. Response to Section 114 Information Request for Nissan Motor Manufacturing Corporation, USA, Smyrna, TN. September 28, 1992.

14. Response to Section 114 Information Request for Subaru-Isuzu Auto Incorporated, Lafayette, IN. September 15, 1992.

15. Response to Section 114 Information Request for Toyota Motor Manufacturing, USA, Inc., Georgetown, KY.

3.0 INDUSTRY DESCRIPTION

This section presents general information on the automotive manufacturing industry, the number and location of assembly plants, the ozone attainment status of the areas in which the plants are located, and a brief description of the assembly and painting processes for a typical automotive assembly plant.

3.1 AUTOMOTIVE INDUSTRY

In 1980, three major auto manufacturing companies--Chrysler Corporation (Chrysler), Ford Motor Company (Ford), and General Motors Corporation (GM)--produced almost all automobile and light-duty trucks made in the United States. In the early 1980's, foreign-based auto manufacturers began building automotive assembly plants in the United States. Today, 10 auto manufacturing companies operate 61 car and light-duty truck assembly plants in the United States.[1]

A list of auto manufacturing companies, the location of assembly plants in the United States, and whether the location is an ozone attainment or nonattainment area is provided in Table 3-1.[1,2]

3.2 AUTOMOTIVE ASSEMBLING PROCESS

A typical auto assembly plant consists primarily of a body shop, a paint shop, a power train assembly area, a trim and final assembly shop, and a final repair and adjustment area for the manufactured vehicles. A simplified automotive production process flow diagram is presented in Figure 3-1. Fundamentally, the process includes (1) stamping, cutting, and welding of sheet or coil steel to form the vehicle bodies; (2) assembling the engine; (3) painting the vehicle bodies; (4) trim and final assembly, which includes installing interior parts, the

TABLE 3-1. AUTO ASSEMBLY PLANTS[1,2]

Company	Location of plant: City, State (type of vehicle)	Ozone attainment status	
		Attainment	Nonattainment
AutoAlliance International, Inc.	Flat Rock MI (car)		Moderate
Chrysler Corp.	Belvidere, IL (car)	Attainment	
	Newark, DE (car)		Severe
	Sterling Heights, MI (car)		Moderate
	St. Louis, MO (car)		Moderate
	St. Louis, MO (light-duty truck)		Moderate
	Toledo, OH (light-duty truck)		Moderate
	Warren, MI (light-duty truck)		Moderate
Diamond-Star Motor Corp.	Normal, IL (car)	Attainment	
Ford Motor Co.	Chicago, IL (car)		Severe
	Dearborn, MI (car)		Moderate
	Edison, NJ (light-duty truck)		Severe
	Hapeville, GA (car)		Serious
	Kansas City, MO (car)		Submarginal
	Kansas City, MO (light-duty truck)		Severe
	Lorain, OH (car)		Moderate
	Lorain, OH (light-duty truck)		Moderate
	Louisville, KY (two light-duty trucks)		Moderate
	Norfolk, VA (light-duty truck)		Marginal
	St. Louis, MO (light-duty truck)		Moderate
	St. Paul, MN (light-duty truck)		Moderate
	Wayne, MI (car)		Moderate
	Wayne, MI (light-duty truck)		Moderate
	Wixom, MI (car)		Moderate
General Motors	Arlington, TX (car)		Moderate
	Baltimore, MD (light-duty truck)		Moderate
	Bowling Green, KY (car)	Attainment	
	Detroit, MI (light-duty truck)		Moderate
	Detroit-Hamtramck, MI (car)		Moderate
	Doraville, GA (car)		Serious
	Fairfax, KS (car)		Submarginal
	Flint, MI (car)		Transitional
	Flint, MI (light-duty truck)		Transitional
	Fort Wayne, IN (light-duty truck)	Attainment	

TABLE 3-1. (continued)

Company	Location of plant: City, State (type of vehicle)	Ozone attainment status	
		Attainment	Nonattainment
General Motors (cont.)	Janesville, WI (light-duty truck)	Attainment	
	Lake Orion, MI (car)		Moderate
	Lansing, MI plant A (car)		Transitional
	Lansing, MI plant B (car)		Transitional
	Lansing, MI (Reatta, car)		Transitional
	Linden, NJ (car)		Moderate
	Lordstown, OH (car)		Marginal
	Lordstown, OH (light-duty truck)		Marginal
	Moraine, OH (light-duty truck)		Moderate
	Oklahoma City, OK (car)		Submarginal
	Pontiac, MI(east) (light-duty truck)		Moderate
	Pontiac, MI(west) (light-duty truck)		Moderate
	Shreveport, LA (light-duty truck)	Attainment	
	Tarrytown, NY (light-duty truck)		Severe
	Van Nuys, CA (car)		Severe
	Wentzville, MO (car)		Moderate
	Willow Run, MI (car)		Moderate
	Wilmington, DE (car)		Severe
General Motors Corp., Saturn Corp.	Spring Hill, TN (car)	Attainment	
Honda of America Mfg., Inc.	East Liberty, OH (car)	Attainment	
	Marysville, OH (car)	Attainment	
New United Motor Mfg., Inc.	Fremont, CA (car)		Moderate
Nissan Motor Mfg. Corp., USA	Smyrna, TN (car)		Moderate
Nissan Motor Mfg., Corp., USA	Smyrna, TN (light-duty truck)		Moderate
Subaru-Isuzu Automotive, Inc.	Lafayette, IN (car)	Attainment	
Subaru-Isuzu Automotive, Inc.	Lafayette, IN (light-duty truck)	Attainment	
Toyota Motor Mfg., Inc., USA	Georgetown, KY (car)		Marginal

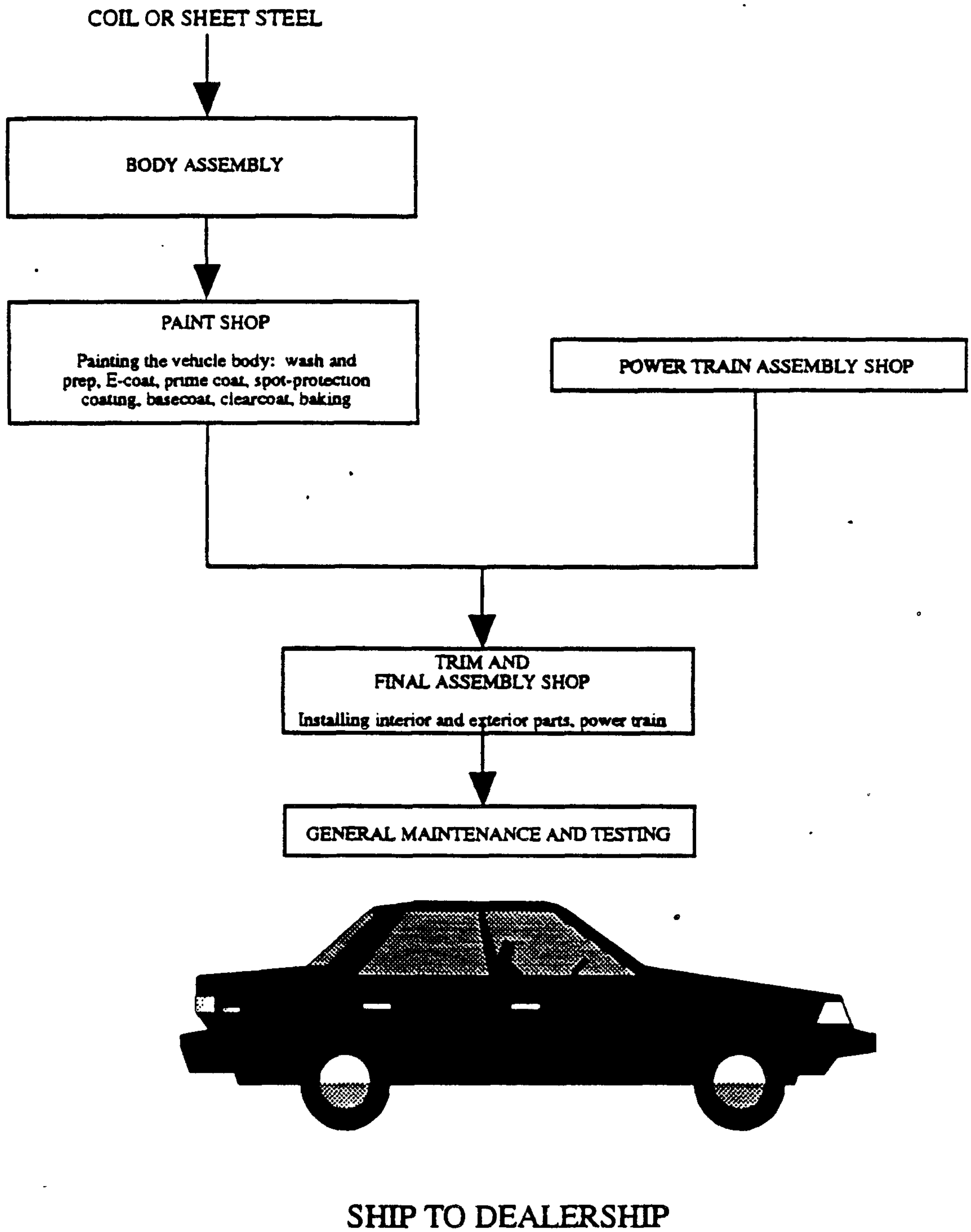

Figure 3-1. Automotive manufacturing process.[3-10]

instrument panel, exterior parts, and the power train, and (5) testing of the vehicle before shipment.[3,10]

3.3 AUTOMOTIVE PAINTING PROCESS

An overview of the painting process, which includes numerous stages, is presented in this section. Although the details of the painting stages vary among the assembly plants, the following major steps are fundamental. These stages are shown in Figure 3-2.[11,12,20]

The process begins with the vehicle bodies undergoing surface preparation and pretreatment. Preparation involves thorough washing and wipe-cleaning. Pretreatment involves application of anticorrosive chemical compounds to the vehicle surface. Generally, this step includes (1) immersion of the vehicle bodies in a phosphate bath, (2) rinsing of the vehicle bodies with chromic acid or acid chromate, and (3) dry-off baking.[11,12,20]

The next step is applying primer to the vehicle bodies. In the majority of the auto assembly plants, the primer is electrodeposited to the vehicle bodies (referred to as electrocoating, or E-coat). After applying the E-coat, the bodies are baked in an oven for 20 to 35 minutes. Next, spray-coated primer or primer-surfacer is applied. Then, sealers and other protective coatings (e.g., polyvinyl chloride [PVC] coating, antichip coating, and/or stoneguard coating) are applied to the appropriate spots on the vehicle bodies. For example, stoneguard coating is applied only to the rocker panels.[11,12,20]

At this point, the vehicle bodies undergo topcoat paint application. Some vehicles are painted in a single color, while others receive two or more colors (two-tone color). Topcoat application includes several stages. These involve automatic (reciprocating or robotic spray) application, or a combination of automatic and manual application of color basecoat and clearcoat, flash-off and bake stages, and repairs. Finally, black paint (referred to as blackout) is applied as accent to certain spots on the car bodies such as the wheel wells and under the grill.[12]

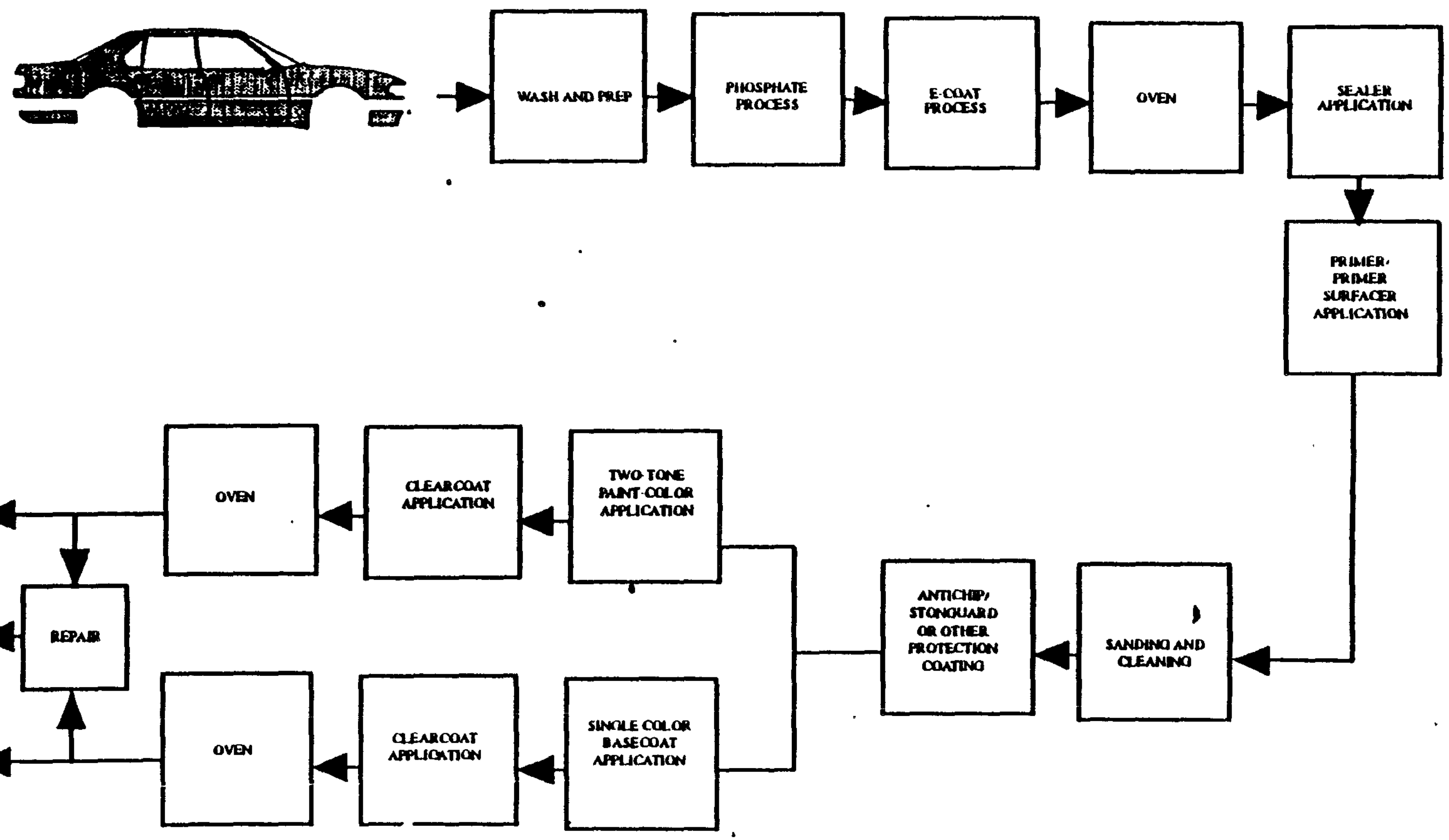

Figure 3-2. Automotive painting process.[11-13]

The majority of the painting stages occur in specifically designated booths. Therefore, a typical paint shop includes a number of booths (or zones within a booth). For example, vehicle bodies are sanded in the "sand-and-prep" booth. Basecoat is applied in the "basecoat" booth, which typically is divided into multiple zones in which specific coating stages are accomplished. These coating stages include coating exterior door jambs, coating the interior door jambs, applying the first body coat, and applying the second body coat. The specific function of the booth determines the relative amount, type, and location of overspray deposits and, hence, the cleaning requirements and cleaning procedures. Detailed information on the paint spray booths and their functions for all of the plants surveyed is provided in Appendix A. Additional information is also provided in the background information document for the New Source Performance Standard for Automotive and Light-duty Truck Surface Coating Operations (EPA 450/3-79-030, September 1979).

3.3.1 Paint Shop Design

Generally, an automotive paint shop consists of a number of booths each dedicated for a specific painting stage. Although painting stages in one plant differ from those in another, some are common to all. One or more booths are used for applying the primer or primer surfacer, the antichip coat (or other types of protective coating), the color basecoat, the clearcoat, and two-tone paint (tu-tone paint). Still other booths are used for spot-repairing of defective paint, and for applying blackout (applying black paint to specific spots on the vehicle bodies such as behind the grill).

Paint shops are designed with either modular or main-color split booths. The difference is in the booths where the basecoat and clearcoat are applied. Each type is briefly described in the following paragraphs.

In shops with modular booths, the vehicle bodies are painted individually with basecoat in one booth and with clearcoat in the next. Usually, after applying primer or primer surfacer in the primer application booth, the vehicle bodies are carried to the modules. The carrier is a single floor conveyor line that splits into branches that feed each module. A module consists of two small spray booths, a flash-off area, and an oven that permits only one vehicle body at a time, as shown in Figure 3-3. In the first booth, the vehicle body is painted with color basecoat. After a short flash-off period (10 to 30 seconds), the vehicle enters the next booth for clearcoat. Then, the vehicle body enters an oven where the paint is baked for 25 to 35 minutes.[11]

In shops with main-color split booths, vehicle bodies are painted in succession with basecoat and clearcoat in one long booth which consists of several zones. As shown in Figure 3-4, the chain of vehicle bodies enters the booth and the bodies are processed in several steps including basecoat application, flash-off, clearcoat application, and baking.[12]

3.3.2 Spray Booth Features

When spray-applied, some paint deposits on the piece and the remaining paint (overspray) either is filtered by the ventilation system or deposits on various booth components (e.g., robots, grates, walls, etc.). Volatile organic compound emissions related to the removal of this deposited paint is the subject of this report. Booth design affects the amount of overspray deposited inside the booth. Each booth is designed for one or several painting stages. Features of individual booths differ depending on function. For example, "blackout" booths are designed for manual application of black paint to specific parts of the vehicle body such as behind the grill. Some of these booths have concrete floors which require different cleaning methods than grate floors.

Any booth feature designed to capture paint particulates (to reduce particulate emissions to the atmosphere) reduces the overspray that deposits on the booth components and must be removed by cleaning. Examples of such features are downdraft and sidedraft waterwash systems. Most booths in auto assembly plants, especially those used for applying basecoat and clearcoat, are designed with a downdraft air flow system.[3-10,13-19] In these booths, a downward air flow is used

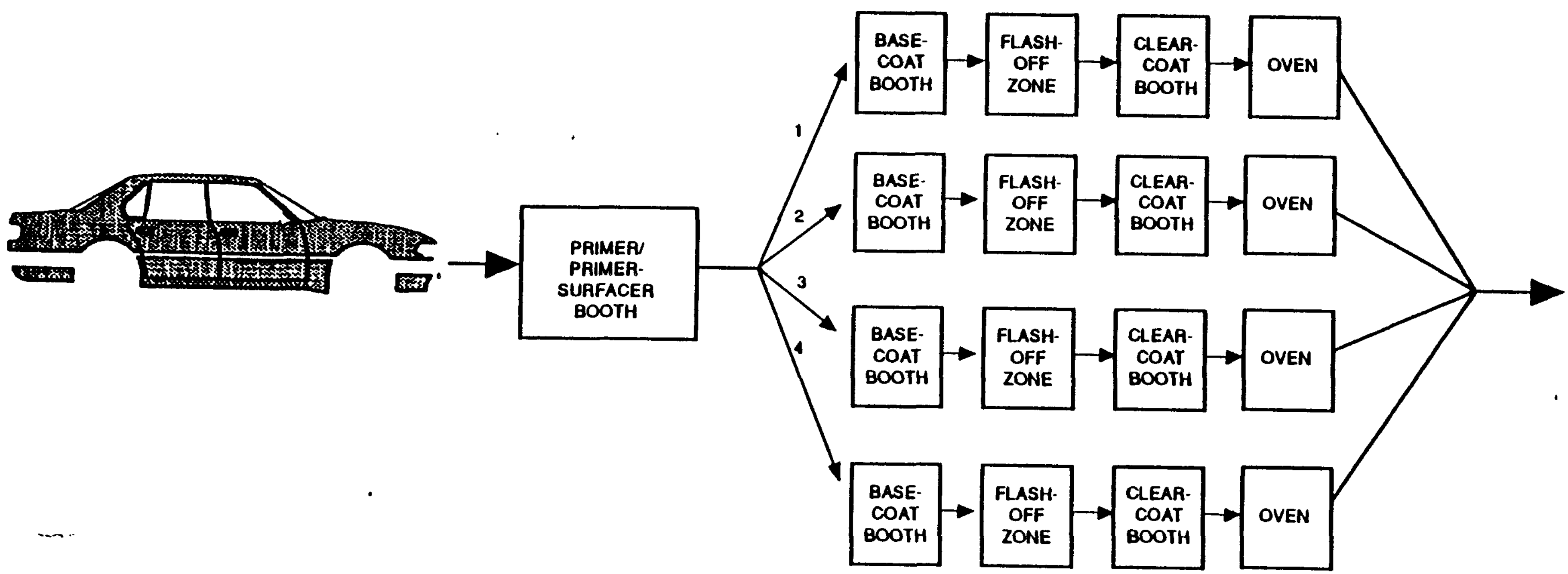

Figure 3-3. Modular paint shop.[11]

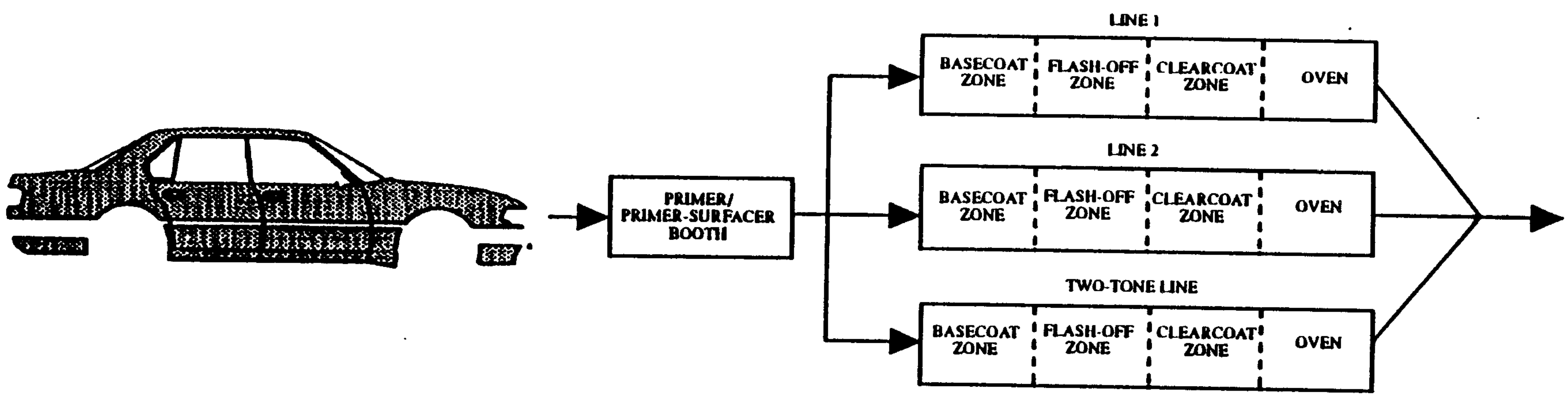

Figure 3-4. Main-color split booth paint shop.[12]

within the booth to capture overspray and move it downward through the floor grates. In a downdraft waterwash system, the air and entrained overspray are directed toward the waterwash (essentially a water pit under the floor grate); overspray impacting the water is collected. The water mixture containing the contaminants flows from the booth to sludge retention pits. In the pits, various chemical compounds, such as detackifiers (chemicals that reduce tackiness of the paint materials), flocculants, and defoamers are added. After chemical treatment, the water and sludge are separated. Then water is returned to the spray booths, while the paint sludge is collected for either further treatment, reclamation, or for shipping to an offsite facility as hazardous or nonhazardous waste.[12,20,21,22]

Spray booths with sidedraft waterwash systems also may be used in auto assembly plants.[14] The sidedraft and downdraft waterwash systems perform similarly. In the downdraft system water flows beneath the grates that comprise the booth floor; the air within the booth flows downward through the grates to the water curtain. In the sidedraft system, the wall on one side of the booth has a water curtain that flows from the top (near the ceiling) to a waterway (stream) on the booth floor. In a sidedraft booth the air flows across the booth and through the water curtain.

Some booths use particulate control arrangements other than a water wash system such as dry filters or scrubbers.[9,14,18,19]

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4.0 CLEANING PRACTICES FOR AUTOMOTIVE PAINT SPRAY BOOTHS

The objective of cleaning a spray booth is to provide a clean environment such that the presence of foreign materials is eliminated to a high degree. Achieving this objective is essential, because dirt in the booth air and on the booth components is a source of contaminates that potentially can mar the wet paint on the vehicle. Cleaning standards for the paint shop exist for both the personnel (e.g., clothing, shoes) and the surroundings. However, in this report, the emphasis is on the latter. This section identifies and describes the booth components which require cleaning, the cleaning practices used, and the factors affecting booth cleaning.

4.1 CLEANING OF BOOTH COMPONENTS

Components of spray booths that are cleaned on a regular basis include walls, windows, floor grates, floors, conveyors or conveyor shrouds, robots and related equipment, tips of the spray equipment, and fixtures (e.g., lights, hoses). These components are common to most spray booths regardless of design (modular or main-color split booths). The frequency of cleaning paint spray booths in an auto assembly plant depends on the rate of paint accumulation and the degree of cleanliness required by the plant.

The amount of overspray accumulation and its location varies for the different booth components. For example, more overspray may accumulate on the robotic arms and spray guns than on walls. Because of their proximity to the vehicles being painted, overspray on robotic arms and spray guns can become the source of contamination that creates defects in the paint. Therefore, robotic arms and spray guns may be cleaned more frequently than walls.

Floors adjacent to spray booths typically are cleaned as a part of the interior booth cleaning process. They are dirtied as paint shop personnel exit the booths; any overspray adhering to shoes is carried outside the booth and tracked onto the floor resulting in "trackout."

Generally, a combination of several cleaning practices is used to clean booth components (and adjacent floors). Certain cleaning practices may be used to clean several types of booth components. For example, in some plants high-pressure water blasting is used to clean walls, windows, and floor grates.

The major and alternative booth cleaning practices used by the auto assembly industry are described in Section 4.2. Application of the cleaning practices to individual components of the booth are discussed in Section 4.3. Factors that affect the cleaning practices are described in Section 4.4.

4.2 CLEANING PRACTICES

A variety of spray booth cleaning activities take place in an auto assembly plant. For the purpose of this report, cleaning "activities" refers to a variety of actions such as wiping, dipping, flushing, spraying, and purging. Cleaning "practices," on the other hand, refers to a repeated or customary action that is specific to an industry. Traditional and alternative cleaning practices are described in Sections 4.2.1 and Section 4.2.2, respectively.

4.2.1 Traditional Cleaning Practices (Based on Solvent)

Traditionally, solvent has been (and continues to be) used in auto assembly plants to clean many spray booth components. Typically, solvent is applied by wiping or spraying major booth components. Small items, like spray equipment tips, are often dipped into a solvent bath.

4.2.2 Alternative Cleaning Practices

A variety of alternative practices also are used either (1) to minimize the solvent required to remove the dried paint or (2) to protect the component from deposition so that cleaning is not required or is minimized. These alternatives may be classified into four groups: (1) mechanical methods, (2) masking agents and protective covers, (3) water-based or low-VOC cleaners, and (4) modified work practices. These practices are described in the following sections.

4.2.2.1 Mechanical Methods.[6,8,11,15,18] Mechanical methods include water blasting and the use of small tools such as brushes, chisels, razor blades, putty knives, and other scrapers, squeegees, or rags. Often small tools are used in conjunction with other alternatives to reduce or eliminate the use of cleaning solvents. When used with solvent, they reduce the amount of solvent necessary. Mechanical methods described in more detail below are (1) spraying of solvents in conjunction with manual use of brushes or rags, (2) wiping with solvent-soaked or dampened rags, (3) scraping with scrapers or chisels, and (4) water blasting.

4.2.2.1.1 Spraying cleaning solvents in conjunction with manual use of brushes or rags. In this practice, the booth component is first wetted (by spraying) with cleaning solvent; then, bristle brushes or cloth rags are used to loosen and remove the paint. Sometimes, squeegees or high-pressure water are used to remove excess solvent.

4.2.2.1.2 Wiping walls with solvent-soaked or dampened rags. In this practice, overspray is removed by manually wiping with solvent-soaked or solvent-dampened rags. The object being cleaned may be sprayed with high-pressure water before and/or after the wiping. The high-pressure water is used before wiping to loosen the paint; water is used after solvent wiping to rinse the cleaned area.

4.2.2.1.3 Scraping with scrapers and chisels. To eliminate the use of cleaning solvents, hand-held scrapers or chisels are used to remove overspray. This practice may be used in conjunction with hot or cold, high-pressure water blasting. Scraping is usually confined to coatings that have a waxy or semipaste texture.

4.2.2.1.4 Water blasting. Water blasting is used in almost all the plants. Water blasting refers to spraying high pressure water. The pressures can be between 500 to 20,000 pounds per square inch (psi). In some plants the water is also heated to 99°C for greater effectiveness. Three configurations of high pressure water are used.

The first consists of portable units with water pressures of less than 6,000 psi. The second is a fixed piping system with water pressures between 6,000 to 9,000 psi. In this system, the high pressure water is supplied through a piping system to spigots located throughout the booth; long-handled spray wands or other types of spray guns are connected to the spigots. The third fully automated system uses water pressure between 10,000 to 20,000 psi, too dangerous for manual operation. The high-pressure water is supplied to automated washers that clean removable booth components (e.g., grates).[9]

4.2.2.2 Masking Agents and Protective Covers. Shielding the surface of booth components from overspray, regardless of the type of shield, is often referred to as either "masking" or "covering"; the terms sometimes are used interchangeably. However, in this report each of these terms refers to a specific type of protective shield.

4.2.2.2.1 Masking Agents.[7,9,15] The term "masking agents" is used to refer to liquid chemical agents (e.g., water-based polymer emulsions) which, when sprayed, form a protective film on the substrate. Several types of masking agents are used depending on the type of paint used, the extent of overspray, and the component being masked. The masking agent may form a dry film ("peelable" coating) or may remain in a tacky semiliquid state ("tacky" coating).

Peelable coatings ("peelcoats") are applied as a liquid and soon form a transparent film covering the clean walls and the windows. Accumulated overspray is periodically removed by peeling the film. Several producers and distributors provide peelcoats designed specifically for the auto industry.

Tacky coatings also are used to facilitate cleaning. A layer of tacky coating is sprayed onto clean walls and windows. The tacky coating provides a loosely adhered moist film on which overspray accumulates. The tacky coating is easier to remove than overspray adhering directly to the bare walls and windows.

4.2.2.2.2 Protective covers.[6,8-10,12,14-19,20] The term "protective covers" refers to a variety of shielding materials used to blanket or wrap booth components. These include: (1) polyethylene (plastic) sheeting and masking cling film; (2) plastic hose-wrappers; (3) aluminum foil; (4) chipboard and cardboard; (5) robot socks and covers; (6) a variety of adhesive tapes such as masking, gray duct, and yellow plastic tapes; (7) tar paper or roofing felt; and (8) a variety of papers such as fireproof and waxed papers. The selection of protective covers depends on the booth component, the type of paint, and the anticipated amount of overspray.

4.2.2.3 Use of Water-Based or Low-VOC Cleaners.[8,15,16] A recent alternative to cleaning solvents is water-based or low-VOC cleaners. These are specially formulated to decrease the VOC content while maintaining the necessary cleaning properties. Typically, these cleaners are sprayed onto the surface to be cleaned. After a waiting period to allow the cleaner to react, some manual method, such as brushing, is used to accelerate the paint removal. Use of water-based or low-VOC cleaners is not yet widespread. Only a few plants are currently trying these cleaners, and several problems have to be resolved. In some cases, manufacturers of these cleaners are willing to modify their products to accommodate specific needs.[2] Several plants now use water-based or low-VOC cleaners for cleaning trackout.

Problems associated with water-based cleaners generally are (1) the time needed to let the cleaners react (which lengthens the time for cleaning); (2) water damage to electrical fittings and equipment, and (3) lower solvency power compared to the organic solvents.[2] Any assembly plant may experience other specific problems, depending on the circumstances under which the cleaner is used.

4.2.2.4 Work Practices. Changes in traditional work practices can reduce the associated VOC emissions. Increased worker training can decrease solvent usage. Examination of practices, such as the frequency of cleaning and acceptable levels of cleanliness, can result in changes that decrease solvent usage. Restricting access and limiting the amount of solvent allocated for specific cleaning activities also have been shown to reduce usage and VOC emissions.[20]

Initiation of a solvent tracking/accounting system has often been a key first step in a management program to reduce usage and emissions. Knowing where solvent is used, how much is used, and how much it costs has helped management identify where any of the alternative cleaning practices described above can be used. This knowledge also identifies where research efforts should be focused to develop acceptable alternatives. Continued tracking is used to document the gains achieved by changing cleaning practices and is a mechanism to assure that those gains are maintained.[20]

4.3 APPLICATION OF CLEANING PRACTICES FOR CLEANING INDIVIDUAL BOOTH COMPONENTS

This section provides a description of the practices used to clean the following booth components: (1) walls and windows; (2) floor grates; (3) fixtures; (4) robots and related equipment; (5) robotic and manual-spray gun tips; and (6) floors adjacent to the booths.

4.3.1 Walls and Windows

Various cleaning practices for walls and windows include (1) water blasting, (2) masking agents, (3) spraying cleaning solvents in conjunction with the use of brushes or rags, (4) wiping the walls and windows with solvent-soaked rags, (5) scraping the walls and windows with hand-held scrapers, (6) the use of water-based cleaners, or (7) a combination of several practices.[1,2,4-19,20]

When a combination of several practices is chosen, the criteria for their selection is based on the nine factors described in Section 4.4 (paint shop design, booth features, etc.) as well as on the specific circumstances of the plant. The following combination of practices is used for walls and windows at one facility. A tacky coating is used to protect the walls and windows from overspray. At days' end, overspray is removed in several steps. First, high-pressure water is used to loosen the tacky coating (and its coating of overspray). Then, solvent is sprayed onto the walls and windows. Next, brushes are used to remove the remaining tacky coating and overspray. High-pressure water again is used to rinse the walls. Finally, a new coat of tacky coating is applied.[1]

4.3.2 Floor Grates

The practice used to clean floor grates depends on whether the grates are removable. Generally, grates are masked with grate coating, which is similar to tacky coating. If the grates are not removable, the cleaning has to be performed inside the booth using either water blasting, scraping, or both.[1]

Removable grates can be cleaned in a variety of ways. Some plants have extra sets to replace the dirty grates. The dirty grates may be cleaned onsite or sent to an offsite cleaning facility. The practices for cleaning removed grates include (1) water blasting, (2) hot caustic baths (hot stripping with sodium or potassium hydroxide), (3) incineration, (4) methylene chloride (cold stripping), and (5) soda blasting (sodium bicarbonate-based medium is used for paint stripping).[21,22]

4.3.3 Fixtures

Practices used for cleaning fixtures, such as lights, conveyors, and conveyor shrouds, are generally a combination of: (1) protective covers or masking agents, (2) cleaning solvents, (3) high-pressure water blasting, (4) tacky coatings, and (5) scraping. Examples of the protective covers used are aluminum foil and masking tape. An example of a masking agent used for conveyors is grease. The scraping is performed using a razor or flat-bladed scraper, or scrapers with brushes.[21]

4.3.4 Robots and Related Equipment

Various types of disposable or reusable covers are available to protect robots and related equipment from paint overspray. Covers may be designed to fit either loosely (loose covers) or tightly (robot socks). The type of cover selected depends on the type of robot and its application. Sometimes, regardless of the type of cover, small areas on robots remain exposed or overspray penetrates the cover (bleeds through). In such cases, the paint is usually wiped off with a rag moistened with cleaning solvents. Protective covers are changed on an as-needed basis. Covers may not be applicable for some robots, specifically those used for overhead electrostatic paint applications.[1,2,4,21]

4.3.5 Robotic and Manual-Spray Gun Tips

Spray guns must be purged with solvents at the end of the day and prior to making a paint color change. In most assembly plants, a closed-loop purging system is used.[23] This system is either connected via a piping system to solvent storage tanks or to an onsite solvent recycling system. Although the purging process was not the focus of this study, cleaning the spray gun tips during normal production hours and at the end of the day is considered part of spray booth cleaning.

The tips of the spray guns are cleaned by wiping them with rags moistened or soaked with solvents. Some of the sensitive devices (bells) at the orifice of the paint spray guns have to be disassembled from the guns so that both the internal and external sides of these devices are cleaned. Typically, immediately after shutdown of the production shift, these devices are disassembled and placed in small solvent baths. Sometimes, small paint brushes are used to remove any remaining paint.

4.3.6 Floors Adjacent to Booths[2]

Floors adjacent to spray booths usually are shielded by a protective cover, masked with permanent masking agents, or protected by a combination of covers and masking agents. In some plants, plastic sheets, a special type of paper, or chipboards are used to cover the floor, and the covers are changed on an as-needed basis. This eliminates or greatly reduces the need to clean the floors. If the floor is masked, the paint overspray is removed more quickly because the paint does not adhere strongly to the masking agent. Masking agents for floors are designed for this purpose. Usually, water-based or low-VOC cleaners are used for cleaning masked floors. A few plants occasionally use solvents to remove tough spots.

4.4 FACTORS AFFECTING CLEANING PRACTICES

Cleaning practices in each plant are somewhat unique. The variations in cleaning practices are due to several factors: (1) spray booth design, (2) paint type, (3) paint application method, (4) robot type, (5) paint application transfer efficiency, (6) time restrictions, (7) cleanliness requirements, (8) labor requirements, and (9) safety concerns.[2]

Although the above factors may cause variations in cleaning practices, they also may provide a common basis for selecting or modifying cleaning practices in a specific plant. Such modifications could result if an auto manufacturing company compares the differences in cleaning practices among several plants within the company to identify successful techniques and to understand the differences in pollution levels. Such comparisons might result in more consistent cleaning practices, or modification of the same practices, yielding a reduction of VOC emissions or a cost savings. The significance of these factors are discussed in the following sections.

4.4.1 Spray Booth Design

The booth design will affect the frequency and method of cleaning. For example, if the booth's grates cannot be removed, the options for cleaning are limited; alternative practices which require removal of the grates are not feasible. Other design elements affect the amount of overspray deposited inside the booth and the difficulty of cleaning. Newer booths are often wider and have higher ceilings to minimize overspray deposited inside the booth. The newer spray booth designs may also substitute glass for stainless steel wherever possible, because glass is easier to clean.[2]

4.4.2 Paint Type

Automotive paint systems are constantly being improved. Changes in the paint systems may require changes in cleaning materials, activities, and practices. In fact, improvement of paint systems may adversely affect current cleaning practices. The more durable a paint system, the more difficult it may be to clean the overspray. For example, the overspray from two-component urethane clearcoats form deposits that are extremely difficult to remove. Consequently, unless a suitable method for protecting the booth components is found, the spray booth requires more frequent cleaning when such coatings are used.[2]

4.4.3 Paint Application Method

The type of paint application, robotic or manual, affects the components of the booth on which the overspray lands. The movement of each robot is limited to the command of a computerized program; hence, it is very predictable. Therefore, the deposition of paint overspray is more predictable and the prevention or cleaning can be systematic. In contrast, manual spraying leads to more random accumulation of overspray, making the prevention of deposition more difficult.[2]

4.4.4 Robot Type

The type of robot affects not only the feasibility of using a protective cover, but also the type of cover that can be used. Overhead robots cannot be covered with a flexible material because as the robot moves, the cover flexes causing paint particles to fall onto the vehicles.[2]

4.4.5 Paint-Application Transfer Efficiency

Transfer efficiency is the ratio of the amount of paint solids deposited on the automobile bodies to the amount sprayed. Transfer efficiency directly affects the amount of overspray that accumulates. The higher the transfer efficiency, the lower the amount of paint overspray. Of course, if less overspray is deposited on the booth components, cleaning needs are minimized. Improvements to and quality control of transfer efficiency can serve to reduce booth cleaning needs.[2,24]

4.4.6 Time Restriction

The duration required for a cleaning practice must be consistent with the time available for booth cleaning; consequently, time constraints affect the feasibility of some cleaning practices. Most cleaning is programmed during the third shift when the assembly line does not operate. Because the assembly lines may run for either two 8- or two 10-hour shifts, the time available for cleaning can vary between 4 to 8 hours.

Time-consuming practices may not be feasible when only 4 hours are available even though the practice may significantly reduce VOC emissions. This is also true for those cleaning practices invoked during production shifts.[2]

4.4.7 Cleanliness Requirements

The cleanliness requirements or standards established by a facility to maintain paint job quality affect the frequency of cleaning required, and may inhibit the use of alternative practices. These internal standards are plant specific and depend on the cleaning needs determined by paint shop managers and engineers. Plant trials will be required to explore the compatibility of the alternative practices and cleaning standards.

4.4.8 Labor Requirements

Labor requirements affect the economic feasibility of some cleaning practices. For example, the use of an alternative practice may require an increase in the number of cleaning crews necessary to complete the job in a specified time. The cost of labor is a consideration in evaluating alternative cleaning practices.[2]

4.4.9 Safety

An important consideration in choosing a cleaning practice is that it must be safe for both operators and equipment. For example, high-pressure water can present a danger to the equipment operator. Similarly, if electrical equipment and fittings in the booth cannot be made water-resistant, water-based cleaners may not be feasible.[2]

4.5 REFERENCES FOR SECTION 4

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5.0 EMISSION ESTIMATION

For this study, the concept of the Unit Operation System (UOS) was used to assist the plants in standardizing the method of selecting boundaries for the requisite material balances and subsequent reporting of information.

This section describes the systematic approach used to calculate VOC emissions from spray booth cleaning. An example calculation is presented.

5.1 UNIT OPERATION SYSTEM CONCEPT[1-5]

Cleaning with solvents in an industrial setting may be perceived on a unit-operation basis. The conventional unit operation, a term common to the chemical engineering discipline, is an industrial operation classified or grouped according to its function in an operating environment. Unit operations vary considerably among industries. Examples include items of traditional production equipment such as a distillation column or a paint mixing vessel (tank). Other less traditional examples could be defined as areas in which manufacturing parts are handled or cleaned, such as a spray booth.

For purposes of material balance calculations, the concept of the unit operation "system," or UOS, extends the boundaries of the conventional "unit operation." The UOS is defined as the ensemble around which a material balance for cleaning can be performed. The boundaries of a UOS should be selected to include all possible points/sources leading to evaporative emission losses associated with cleaning the specific unit operation, including losses during dispensing the solvent, spilling virgin and used solvent, handling residual solvent in cleaning applicators, etc. Emissions from "secondary" sources, such as in plant waste management (e.g., recycling or subsequent treatment) are to be determined by defining separate UOSs.

A material balance is a mathematical statement that expresses the law of conservation of mass (i.e., at equilibrium, the mass that flows into a process, or UOS, equals the mass out). It is a calculation technique that can be used to predict the quantity or composition of one stream when all others flowing in and out of the UOS are known.

The UOS approach has two interdependent requirements: a well-defined system boundary and sufficient and reliable quantitative information on the amount of VOC that enters and exits those boundaries. The material balance is performed by determining their difference. The VOC input, often virgin solvent, can be quantified from usage records based upon some type of solvent metering system, usage inventory or operator log. Accurately quantifying the liquid VOC that exits is more complicated and involves a number of steps because the waste solvent contains contaminants removed by the cleaning. To quantify the VOC in the waste solvent requires analytical tests to provide a "waste profile."

In addition to providing an approach for quantifying baseline emissions, the UOS approach can help identify and quantify benefits of alternative pollution prevention activities.

5.2 SPRAY BOOTH UNIT OPERATION SYSTEM

Figure 5-1 shows a spray booth UOS for an example booth in an auto assembly plant. All inputs for a spray booth are considered; each feed solvent is indicated by S_1, S_2, S_3,...,S_n, while all outputs (the waste solvents that leave the booth) are designated as W_1, W_2, and W_3. Each symbol defines a specific method of treatment or disposal as follows: W_1 refers to any waste solvent sent offsite for reclamation or disposal; W_2 refers to any waste solvent treated onsite for reclamation; and W_3 refers to recycled waste solvent. The difference between the total VOC's in the feed and in the wastes is presumed to be emissions that will ultimately reach the atmosphere as (1) fugitive emissions or (2) vented emissions. The former may

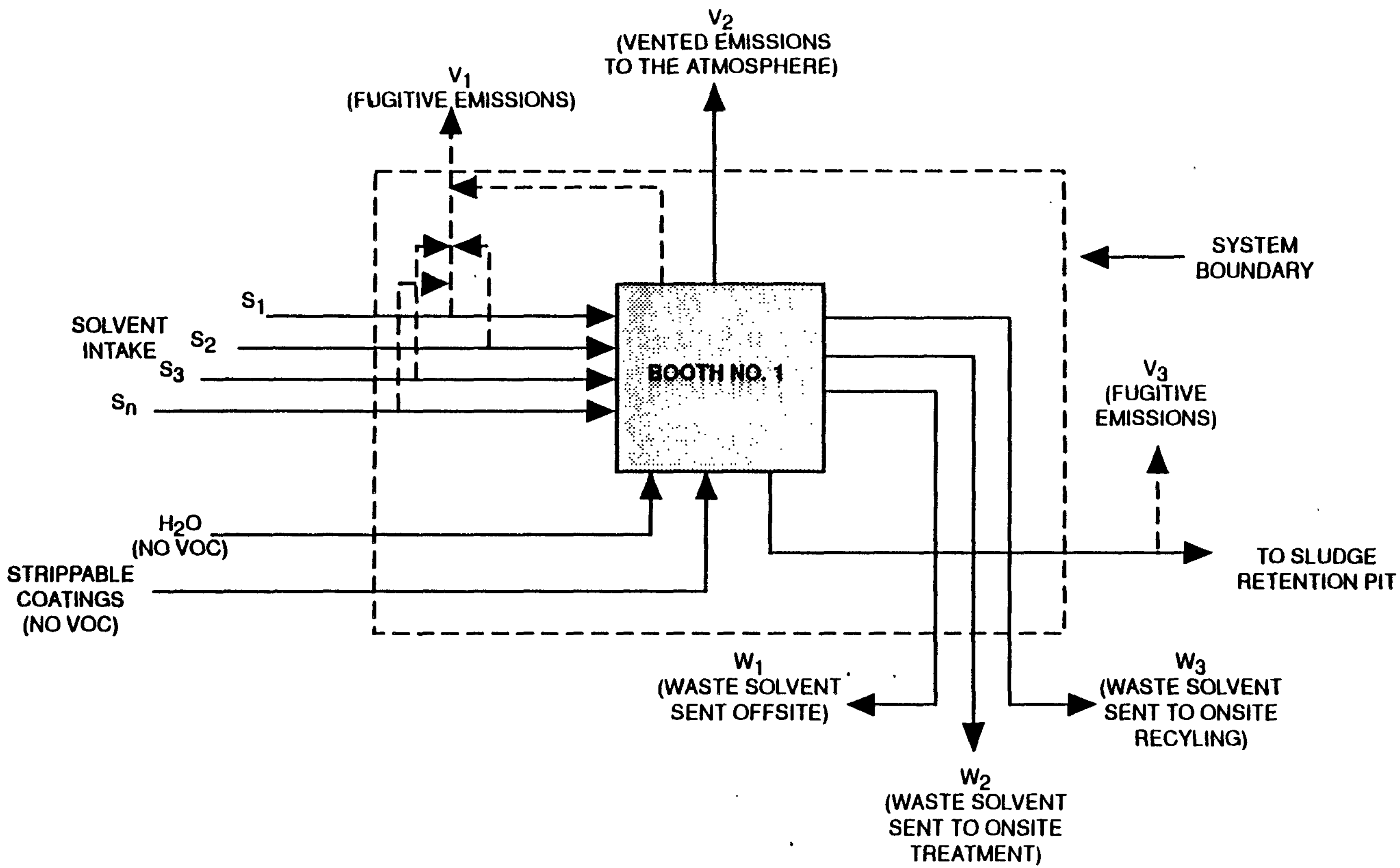

Figure 5-1. Schematic of a spray booth cleaning unit operation system.

occur directly from the unit operation or, for waterwash booths, may take place later as the water and paint sludge are separated.

The VOC material balance for Figure 5-1 is as follows:

VOC in solvent used = VOC emitted + VOC in waste (1)

or

VOC emitted = VOC in solvent used - VOC in waste. (2)

Therefore, the following equation is used to calculate the VOC emissions during a given period of time:

$$V_T = V_1 + V_2 + V_3$$
$$= S_1R_1 + S_2R_2 + S_3R_3 + \ldots + S_nR_n - (W_1R_{w1} + W_2R_{w2} + W_3R_{w3}) \quad (3)$$

where:

V_T = total VOC emissions, pounds (lb);

V_1 = fugitive VOC emissions, lb;

V_2 = vented VOC emissions, lb;

V_3 = fugitive VOC emissions from water discharge to sludge retention pit (waterwall booths), lb;

$S_1, S_2, S_3, \ldots, S_n$ = volume of cleaner used to clean the booth, gallons (gal);

$R_1, R_2, R_3, \ldots, R_n$ = weight fraction of VOC constituents in the corresponding cleaner, lb VOC/gal cleaner;

R_{w1}, R_{w2}, R_{w3} = weight fraction of VOC constituents of each of the waste streams, W_1, W_2, W_3, lb VOC/lb waste; and

W_1, W_2, W_3 = pounds of waste generated for each waste stream.

Figure 5-2 shows the UOS for a hypothetical spray booth equipped with an air pollution control device that is operated during cleaning. In this case, the material balance is conducted using equation 4:

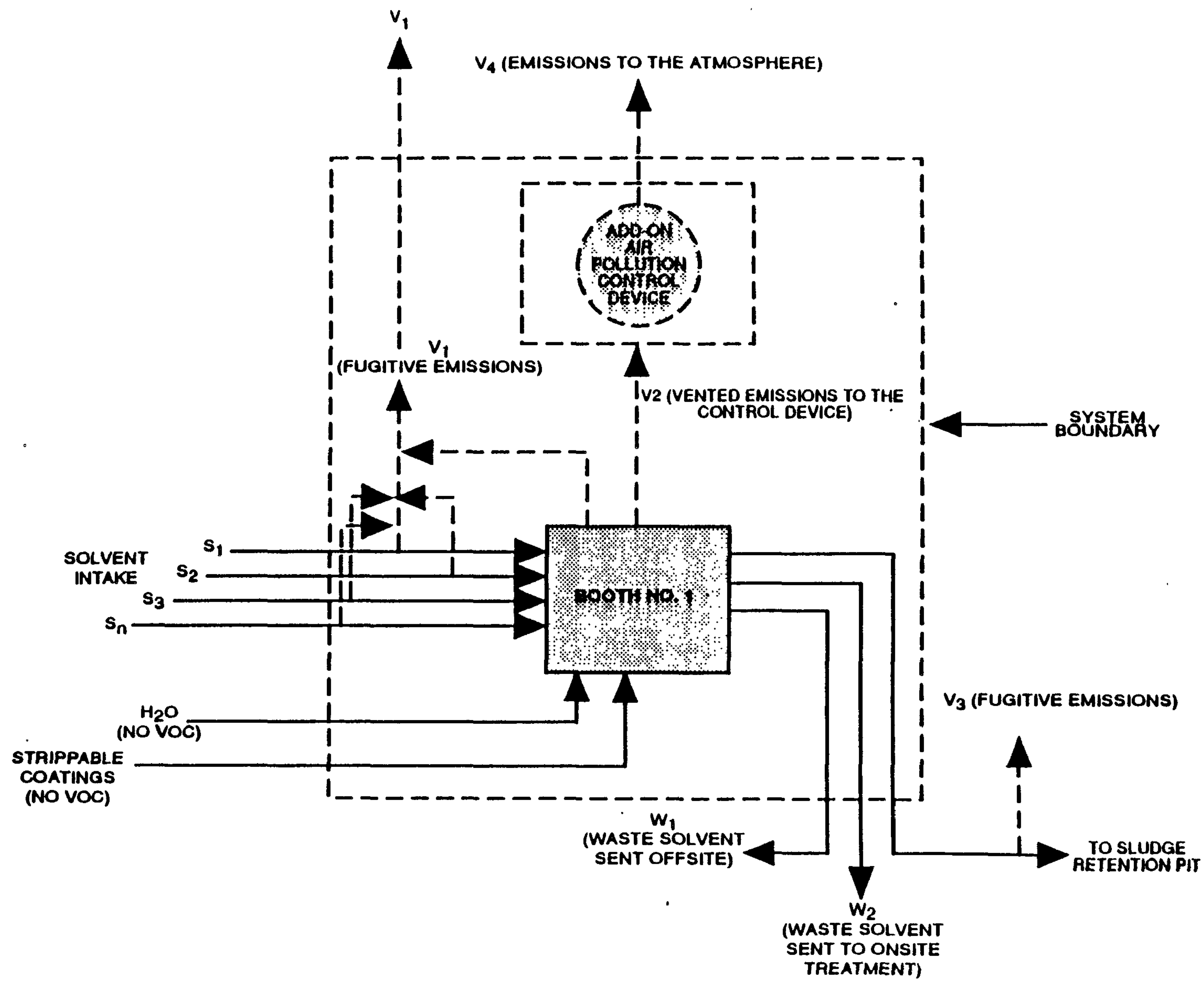

Figure 5-2. Schematic of a spray booth cleaning unit operation system with add-on air pollution control.

$$V_T = V_1 + V_3 + V_4 \quad (4)$$

where:

$$V_4 = V_2 (1 - E) \quad (5)$$

and V_4 and E are defined as follows:

V_4 = VOC emissions vented from a control device, lb, and

E = destruction or removal efficiency of the control device, percent.

Inserting equation 5 into equation 4 yields:

$$V_T = V_1 + V_2 (1 - E) + V_3 \quad (6)$$

Note that VOC emissions from UOS wastes (i.e., W1, W2, W3) may occur during storage, handling, and treatment of these wastes; however, due to the boundaries that have been used to define the UOS for this study, these emissions are not included as spray booth cleaning emissions. In practice, one should consider that the storage, handling, and treatment of these wastes are potential emission sources. Also note that, for this study, purging of paint lines and spray guns during the automobile painting process has been considered a separate cleaning UOS and is not considered a part of booth cleaning emissions. Emissions from gun purging occur inside a spray booth during a time frame (during operation of the paint line) different than the booth cleaning (typically when the paint line is not operating). Thus, for this study, a distinction was made between emissions due to booth cleaning and emissions from gun cleaning even though both cleaning activities result in emissions from a spray booth.

5.3 APPLICATION OF THE UOS CONCEPT TO THE SPRAY BOOTH CLEANING SYSTEM

Completing a material balance for a spray booth UOS is the most efficient way for a plant to estimate emissions from cleaning exposed surfaces within the spray booth. Also, use of the UOS approach can provide valuable information on the amount of solvent being used for specific cleaning practices. This may assist plant management in identifying acceptable cleaning practices that maximize VOC reductions.

Although application of the UOS concept is essentially the same for every plant, their may be need to define one or more subcategories of the spray booth UOS. In this case, the UOS boundaries also need to be established consistently across the industry. The factors affecting the boundaries chosen include the number and design of the spray booths, the types of solvent and waste records that are maintained or need to be established, and the cleaning procedures used. It is important that a plant pay particular attention to and be specific in defining UOS boundaries and details. Theoretically, as a smaller, unique entity of the entire system is defined as the UOS being studied, more specific and useful information may be obtained. For example, if the UOS being studied is defined as cleaning all robots within a spray booth, application of the UOS concept will result in the determination of the amount of solvent used (and emissions created) to clean robots. On the other hand, if the UOS is defined as the spray booth, application of the concept, may or may not yield specific information on the amount of solvent used and the resultant emissions from cleaning the robots. If, for example, multiple components within the booth (e.g., robots and walls) are cleaned using the same solvent, then a material balance around the booth will not yield specific information on emissions resulting from robot cleaning unless care is taken to obtain separate solvent usage (and waste) data on the amount used for robot cleaning and that for wall cleaning. If, on the other hand, different, unique solvents are used for cleaning robots, a material balance around the booth will also yield emissions information specific to robot cleaning. Similarly, if a facility has three identical booths which are operated and cleaned in an identical manner, a UOS comprised of the three booths should yield an average value as useful as information obtained by defining a separate UOS for each individual booth.

In addition to defining the system boundaries, other major variables essential to success include the records maintained to determine solvent usage and waste discharge, and the cleaning procedures used. Consideration must be given to the time period for which usage records are needed to determine the material balance (e.g. per shift, per day, per week, or per year). If different procedures are used for daily cleaning and annual cleaning, separate material balances may be needed and usage records may need to be maintained separately for each type of cleaning.

Inputs should be based upon documented usage. Usage may be based on metering devices or operator log records. Usage may be evaluated from inventory or purchasing records when one or more solvents is used only for the cleaning unit operation system. However, some solvents have multiple uses such as thinning paint, purging spray guns, and/or other uses in addition to cleaning. Ideally, the amount used for booth cleaning will be monitored and recorded separately to provide accurate usage records. If the amount used for booth cleaning is not monitored/recorded separately, the plant will have to estimate usage. The amount used for all other purposes should also be independently estimated, and the sum of the amounts used for each purpose should be compared with the known total usage from purchasing or other records to confirm that the estimates have merit.

Outputs may also vary considerably depending on whether spent solvent is collected and the types of records that the plant maintains. Solvent used for booth cleaning is rarely collected for reuse, recycling, treatment, or disposal. In cases where no waste solvent is collected, it can be assumed that all solvent ultimately enters the air as fugitive emissions. When solvents are collected (for disposal or whatever other purpose as shown in Figures 5-1 and 5-2), the plant records might report amounts from individual booths or groups of booths, or the waste solvent might be combined with other cleaning and/or process wastes before quantification. As with solvent usage, when the only available records are for total waste, the plant needs to measure or use sound judgement to estimate not only the amount

from the spray booth UOS, but also from all other sources to provide a crosscheck.

Since most plants do not vent emissions from booth cleaning to a control device, all losses unaccounted for are considered to be fugitive emissions. Solvents collected in the waterwash fall into this category and are considered fugitive emissions.

In summary, in applying the UOS concept to a spray booth, careful consideration must be given to defining system boundaries, as well as to establishing the criteria for usage and waste records so that the desired information is obtained. At the same time, a practical approach to information collection should be maintained. Furthermore, when evaluating solvent usage for multiple booths and/or an entire plant, the sums of the amounts used for all UOS should be totaled and compared to plantwide records, purchases, etc. to provide a common sense check.

5.4 APPLICATION OF THE UOS CONCEPT TO THIS STUDY

The information provided for this study by the plants varied widely with respect to how the UOS's were defined and the type of input and output records used. Some facilities defined UOS on an individual booth basis; others defined the UOS as all booths in the paint shop. Some facilities provided solvent input information based on actual usage records for the booths, while others provided information based upon inventory records and usage estimates.

Figure 5-3 shows an example of a completed spray booth UOS for the GM (Fort Wayne) plant. The plant defined the system boundary to encompass the 10 modular basecoat/clearcoat spray booths at the plant. Within the boundary are all activities associated with cleaning the surfaces of booth components inside the spray booth. The material balance for this plant is presented on a daily basis. Inputs consist of four VOC solvents that are used in each of these booths. The plant also uses a

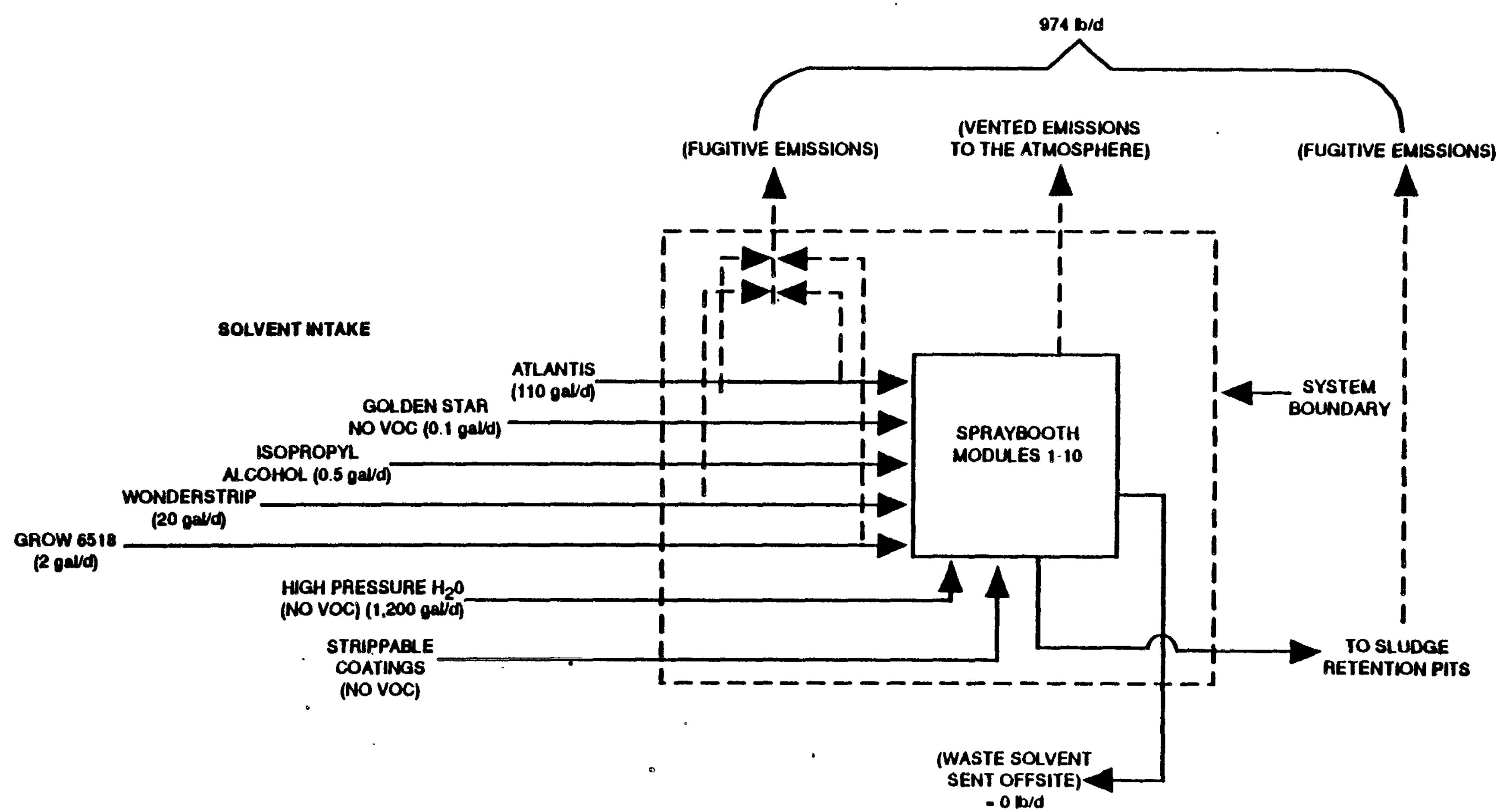

Figure 5-3. Schematic of spray booth cleaning unit operation system for GM (Fort Wayne).[6]

non-VOC cleaner, strippable coatings, and high pressure water, but these do not contain VOC. Since no waste solvent is collected from these booths and the plant does not vent emissions to an operating control device, all usage can be assumed to result in fugitive air emissions. Equation (3) can be simplified as follows:

$$V_T = V_1 = S_1R_1 + S_2R_2 + S_3R_3 + S_4R_4 \qquad (7)$$

where:

S_1 = 110 gal/d of Atlantis Booth Stripper
R_1 = 7.4 lb/gal for Atlantis Booth Stripper
S_2 = 0.5 gal/d of isopropyl alcohol
R_2 = 6.5 lb/gal for isopropyl alcohol
S_3 = 20 gal/d of Wonderstrip Floor Cleaner
R_3 = 8.5 lb/gal for Wonderstrip Floor Cleaner
S_4 = 2 gal/d of Grow 6518
R_4 = 6.9 lb/gal for Grow 6518

Inventory records and purchasing disbursement history were used by GM to determine the daily usage of each of the VOC solvents. Substituting these values in equation (7) shows the total VOC emissions from cleaning these 10 booths are almost 1,000 lb/d.

5.5 REFERENCES FOR SECTION 5

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6.0 SOLVENT USES AND VOC EMISSIONS AT SURVEYED PLANTS

This section describes the ways in which solvent was used in 1991 for cleaning spray booth components at 15 surveyed plants. Also presented are the quantities of both the solvent usage and VOC emissions associated with this cleaning. The section concludes with a discussion of normalized emissions and emission factors.

6.1 SOLVENT USAGE FOR SPRAY BOOTH CLEANING

Table 6-1 shows, for each plant, the spray booth components cleaned with solvent, the method and frequency of cleaning, the number of booths in which the cleaning is performed, and the total solvent used. Unfortunately, with few exceptions, the amount of solvent used to clean individual spray booth components was not available. Although use of low VOC cleaners can be considered an alternative practice, they are shown in Table 6-1 because of their contribution to the total VOC emissions.

Spray equipment tips are the component cleaned with solvent by the most plants. All but two of the plants clean all spray equipment tips by spraying or wiping with solvent or dipping in solvent. The two exceptions are for auxiliary (i.e., not the main primary, topcoat, or repair) booths, as described in Section 7.6.

Robots (and related equipment) and windows are the components cleaned with solvent by the second highest number of plants. Only AutoAlliance did not use solvent to clean robots, and only Chrysler (Belvidere) and Ford (Dearborn) did not use solvent to clean windows.[1,2,6] Robots in a wax application booth were the only ones cleaned with solvent by Subaru-Isuzu.[14]

TABLE 6-1. USES AND USAGE OF SOLVENT AND LOW VOC CLEANERS AT SURVEYED PLANTS IN 1991

Plant No.	Plant	No. of booths	Solvent uses by booth component[a]								Solvent usage, gal/yr (l/yr)
			Walls	Floors	Grates	Robots/ equipment	Spray equipment tips	Windows	Fixtures	Personnel	
1	AutoAlliance	16	Wipe and scrub uncovered sections where over-spray is light			After scraping, any residual paint is removed by wiping. "Jigs" soaked	Some wiped with sponges or scrubbed with brushes at end of production shifts. Others soaked in solvent	Scrub with sponges after spraying from squeeze bottle			14,600 (55,300)
2	Chrysler (Belvidere)	4		Mop daily the tile floors in clean rooms surrounding the booths		Wipe about 65 percent of equipment area in three booths daily	Wipe at end of second production shift and occasionally during production shifts (3,800 gal/yr)		"Flood" low VOC cleaner onto center track drive covers daily (3,477 gal/yr)		47,447 (179,600)
3	Chrysler (Dodge City)	7	Spray in three booths	Mop some uncoated areas		Wipe as needed	Wipe throughout the day and at end of production shifts with lint free cloth or brushes	Spray in three booths Pump bottle spray low VOC in one booth			66,525 (251,830)
4	Chrysler (Sterling Heights)	6	Wipe peelable coating in four booths nightly Wipe uncovered stainless steel walls daily in repair booth			Some wiped	Wipe at end of production shifts	Brush on and squeegee off every night in 5 booths			25,656 (97,120)
5	Ford (Chicago)	7	Scrub with low-VOC cleaners once/week in four booths			Spray 4 times/d and wipe clean	Ultrasonic bath	Scrub with low-VOC cleaner (or solvent) once/wk	Scrub with low-VOC cleaner (or solvent) once/week		99,502 (376,660)
6	Ford (Dearborn)	5	Spray with low VOC cleaner in one booth	Mop daily in three booths		Wipe as needed in two booths	Wipe daily in three booths				5,278 (19,980)

TABLE 6-1. (continued)

Plant No.	Plant	No. of booths	Solvent uses by booth component[a]								Solvent usage, gal/yr (l/yr)
			Walls	Floors	Grates	Robots/ equipment	Spray equipment tips	Windows	Fixtures	Personnel	
7	Ford (Twin Cities)	7	Spray and scrub twice/week in three booths Pump bottle spray once/ month in one booth	Mop daily in three booths		"Wash" nylon covers Wipe exposed areas 4 times/d Clean manual guns hourly in gun cleaning stations	Soak and manually scrub daily in a dip tank	Spray twice/wk in four booths Spray low VOC from squeeze bottle once/month in one booth			98,139 (371,500)
8	GM (Fort Wayne)	23	Spray once a week where paint has penetrated the tacky coating and was not removed with high pressure water blasting	Mop floors outside booths	Same as walls	Wipe uncovered areas	Wipe at end of production shifts	Same as walls			53,086 (200,950)
9	GM (Moraine)	12	Spray about once a week		Touch up cleaning daily	Spray and wipe turbobells four times/shift	Spray and wipe four times/shift	Spray about twice/week			>189,517 >717,400)
10	GM (Oklahoma City)	7		Mop daily (2,800 gal/yr)		Spray inaccessible areas Wipe turbobells	Either soak or wipe at end of production shifts	Some are wiped	Most are wiped, some are sprayed	Boots & gloves are wiped	97,696 (369,820)
11	Honda (East Liberty)	N/A	Wipe uncovered sections or areas where paint penetrated plastic covering once/d in major booths and once/wk in others	Spot clean		Wipe some uncovered areas	Wipe some at end of production shifts	Wipe some	Wipe some		31,807 (120,400)

TABLE 6-1. (continued)

Plant No.	Plant	No. of booths	Solvent uses by booth component[a]								Solvent usage, gal/yr (l/yr)
			Walls	Floors	Grates	Robots/ equipment	Spray equipment tips	Windows	Fixtures	Personnel	
12	Honda (Marysville)	32	Wipe daily in six wax application booths Wipe uncovered areas daily in six repair booths			Wipe daily in one wax booth Wipe daily in three major booths	Wipe at end of production shifts	Wipe daily in 14 booths		Wipe air helmets and face shields daily in 10 booths Clean hands daily in six repair booths	184,400 (698,000)
13	Nissan	6	Spot clean one booth once/wk	Spot clean in one booth Mop with low-VOC cleaner in five booths		Wipe daily in five booths	Wipe daily in five booths	Wipe daily in five booths	Wipe daily in five booths		41,934 (158,740)
14	Subaru-Isuzu	7				Wipe in one wax booth	Dip at end of each shift	Wipe in five booths			10,250 (38,800)
15	Toyota	22	Wipe heavy overspray daily in eight booths Spray occasionally heavy overspray in four of the eight booths			Wipe daily in seven booths	Wipe as needed in 20 booths	Wipe heavy overspray daily in eight booths Spray purge thinner in three booths	Wipe heavy overspray daily from lights	Clean hands and personal protective equipment occasionally	282,289 (1,068,590)

[a]Blanks signify no solvent was used to clean the booth component.

The components cleaned with solvent by the fewest plants were grates and personnel (hands and personal protective equipment). Only GM (Fort Wayne) and GM (Moraine) used solvent for cleaning grates, and only at Honda (Marysville) and Toyota did personnel routinely use solvents to clean themselves.[8,9,12,15]

6.2 EMISSIONS

The plants were asked to report (1) the total VOC emissions from spray booth cleaning and (2) the quantity of each solvent used for spray booth cleaning. In addition, they were asked to develop UOS's (for individual or multiple spray booths) following the procedures described in Section 5. With the material balances for these UOS's, they were to calculate emissions for each solvent in each UOS. Total emissions per UOS were estimated by summing the emissions of the individual solvents.

Nine of the plants developed UOS's; some lumped all booths into one UOS, and others developed UOS's for individual booths as well as multiple booths.[1-8,15] For the other six plants, booth cleaning emissions were calculated from plantwide usage and waste data provided by the plant; in effect, a UOS was developed for the entire plant.[9-14]

The expectation was that the sum of the VOC emissions for each solvent from the UOS's would equal the reported total VOC emissions from booth cleaning. When discrepancies or data gaps were noted, the plants were asked for clarifications. The resulting actual spray booth cleaning emissions in 1991 are shown in Table 6-2. They ranged from about 14 to 940 ton/yr (13 to 850 Mg/yr), or over a range of nearly two orders of magnitude. Emissions for most plants are based on estimates of (1) usage distribution between process (or other cleaning) uses and spray booth cleaning uses and (2) the amount of collected spent solvent. However, emissions for two plants are more uncertain than the others because those plants did not clarify all discrepancies in their reported data. The facility profiles in Appendix B present the reported and calculated data and the assumptions used to determine emissions for each plant.

TABLE 6-2a. ACTUAL, NORMALIZED, AND PERMITTED VOC EMISSION LEVELS AT THE SURVEYED PLANTS IN 1991 (English Units)

Plant	Ref.	Booth cleaning VOC emissions: Actual emissions, tons/yr	Booth cleaning VOC emissions: Actual shifts per year	Booth cleaning VOC emissions: Normalized emissions, tons/yr at 500 shifts/yr	Plantwide VOC emissions, tons/yr: Actual	Plantwide VOC emissions, tons/yr: Permitted
Ford (Dearborn)	6	14	270	26	292	1,323
Subaru-Isuzu	14	35	490	36	813	1,506
AutoAlliance	1	45	500	45	1,460	3,474
Ford (Twin Cities)	7	78[a]	390	100	556	934
Chrysler (Sterling Heights)	4	86	310	139	586	3,803
Honda (East Liberty)	11	114	500	114	775	2,529
Nissan	13	146	480	152	1,297	2,296
Chrysler (Belvidere)	2	160	430	211	1,015	4,485
GM (Ft. Wayne)	8	193	404	239	1,052	2,931
Chrysler (Dodge City)	3	228	430	265	1,210	3,614
GM (Oklahoma City)	10	251	440	285	1,196	2,050
Ford (Chicago)	5	347	420	413	1,009	1,009
GM (Moraine)	9	>657[b]	450	>730	1,398	3,204
Honda (Marysville)	12	671	500	671	2,956	5,152
Toyota	15	940	480	979	2,219	6,196

[a]The plant reported total booth cleaning emissions of 78 tons/yr. However, there are unresolved discrepancies between the reported usage levels and the inputs to the material balance that makes this value uncertain.

[b]The plant reported total booth cleaning emissions of 139 tons/yr and 750 tons/yr in different parts of their response. Based on the usage data and assuming no spent solvent is collected, the emissions were calculated to be at least 657 tons/yr and could be as high as 681 tons/yr.

TABLE 6-2b. ACTUAL, NORMALIZED, AND PERMITTED VOC EMISSION LEVELS AT THE SURVEYED PLANTS IN 1991 (Metric Units)

		Booth cleaning VOC emissions			Plantwide VOC emissions, Mg/yr	
Plant	Ref.	Actual emissions, Mg/yr	Actual shifts per year	Normalized emissions, Mg/yr at 500 shifts/yr	Actual	Permitted
Ford (Dearborn)	6	13	270	24	265	1,201
Subaru-Isuzu	14	32	490	32	738	1,367
AutoAlliance	1	41	500	41	1,330	3,154
Ford (Twin Cities)	7	71[a]	390	91	505	848
Chrysler (Sterling Heights)	4	78	310	126	532	3,453
Honda (East Liberty)	11	104	500	104	704	2,296
Nissan	13	133	480	138	1,180	2,085
Chrysler (Belvidere)	2	145	430	191	922	4,072
GM (Ft. Wayne)	8	175	404	217	955	2,661
Chrysler (Dodge City)	3	207	430	241	1,098	3,282
GM (Oklahoma City)	10	228	440	259	1,086	1,861
Ford (Chicago)	5	315	420	375	916	916
GM (Moraine)	9	>597[b]	450	>663	1,270	2,909
Honda (Marysville)	12	609	500	609	2,684	4,678
Toyota	15	850	480	889	2,015	5,676

[a]The plant reported total booth cleaning emissions of 71 mg/yr. However, there are unresolved discrepancies between the reported usage levels and the inputs to the material balance that makes this value uncertain.

[b]The plant reported total booth cleaning emissions of 126 mg/yr and 680 mg/yr in different parts of their response. Based on the usage data and assuming no spent solvent is collected, the emissions were calculated to be at least 597 mg/yr and could be as high as 618 mg/yr.

The VOC emissions from spray booth cleaning are presented graphically relative to reported plantwide total VOC emissions and total permitted VOC emission levels in Figures 6-1 and 6-2, respectively. (Note that all but Plant 5 have considerable expansion room within their permits.) Figure 6-1 shows the VOC emissions from spray booth cleaning ranged from 3 to 47 percent of the reported total plantwide VOC emissions. Figure 6-2 shows that VOC emissions from spray booth cleaning ranged from 1 to 34 percent of the plantwide permitted VOC emission levels.[1-15]

6.3 NORMALIZED EMISSIONS AND EMISSION FACTORS

Each plant reportedly operated 2 shifts per day, 5 days per week, and about 8 hours per day. The number of operating weeks per year, however, ranged from 27 to 50. Because most cleaning is performed on a weekly (or more frequent) basis, normalized annual emissions were developed for 50 weeks (or 500 shifts) of operation per year. (This normalizing procedure does not account for the impact that the capacity may have; the more vehicles painted, the more cleaning that may be required and the greater the cleaning emissions.) After normalizing the emissions, only two of the fifteen plants switched places in the ranking, as shown in Table 6-2; the same general trend is evident. A graphical representation of both the actual and normalized emissions is shown in Figure 6-3.

6.3.1 Qualitative Comparison of Emissions

Figure 6-3 shows Plants 9, 12, and 15 have much higher emissions than the other plants. It also shows Plants 1, 6, and 14 have much lower emissions. Without considering factors like the amount of area cleaned per booth (because of booth design features or the extent of protective cover usage), the design of the spray equipment, the amount of overspray, the type of paint, and in some cases the frequency of cleaning, it is difficult to explain the enormous variation. A few generalizations, however, can be drawn from the information shown in Table 6-1 about cleaning activities, the number of booths in which solvents are used, the booth components cleaned with solvent, and the frequency of cleaning.

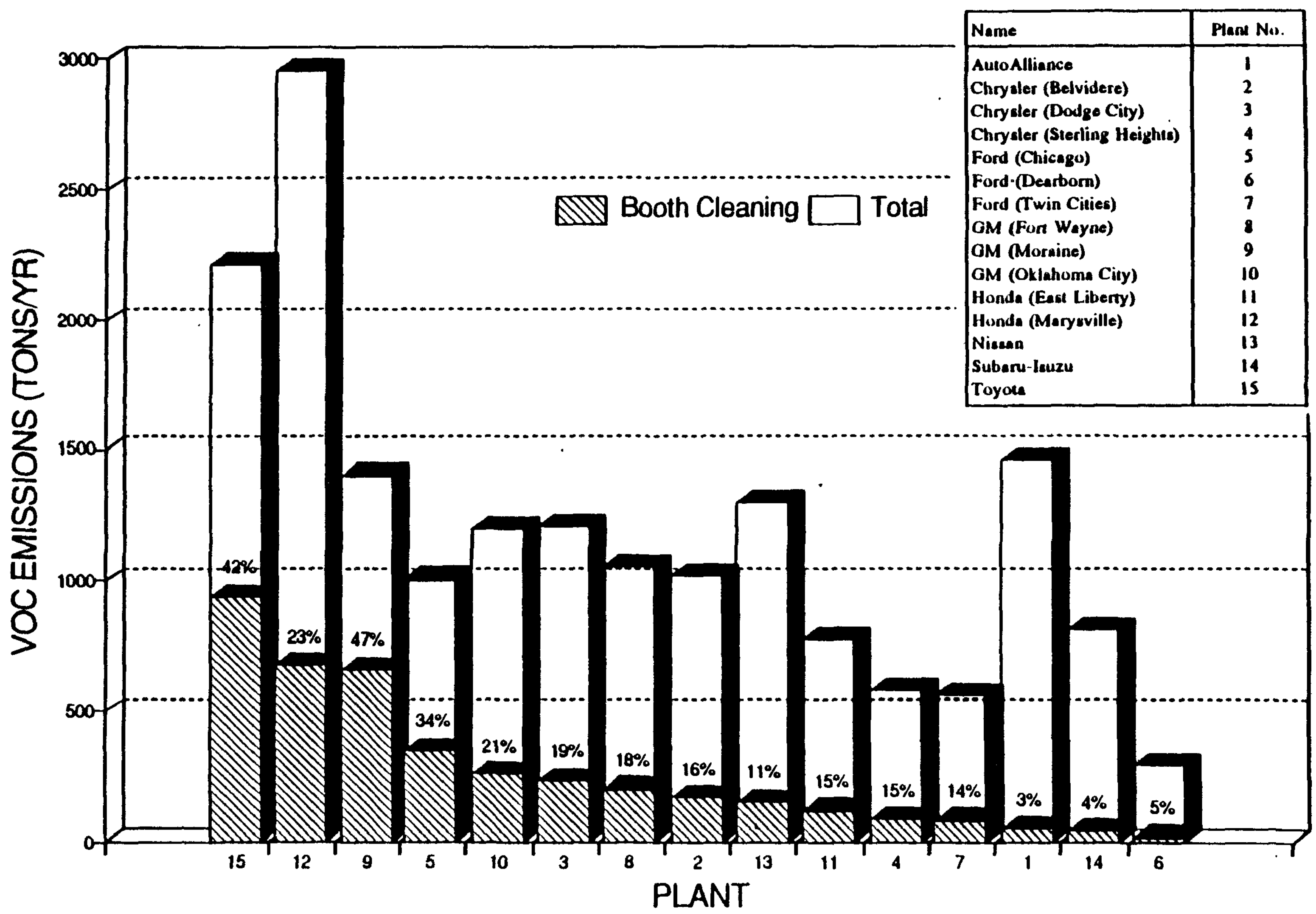


Figure 6-1. Reported VOC emissions from spray booth cleaning relative to total plantwide VOC emissions in 1991.

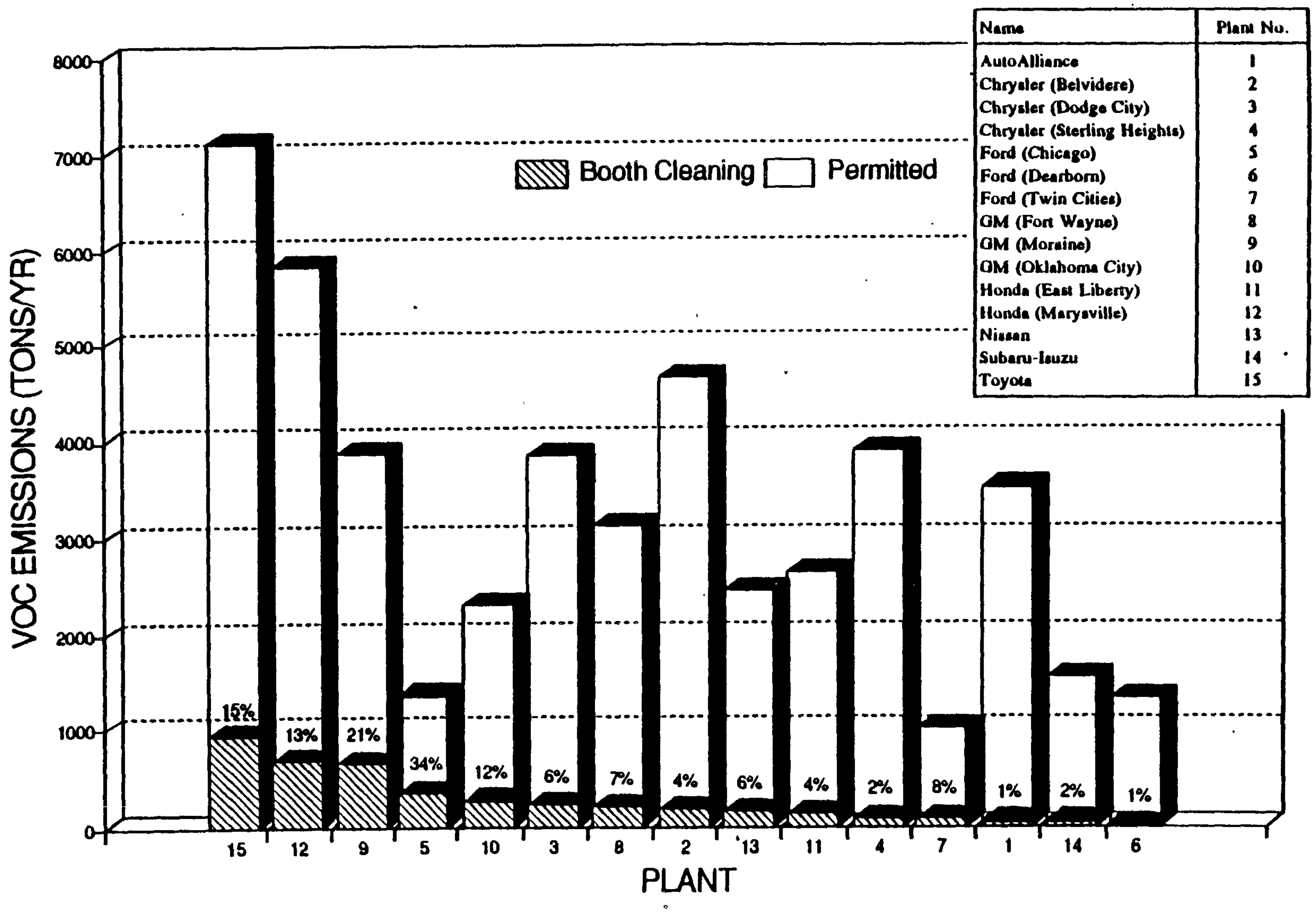
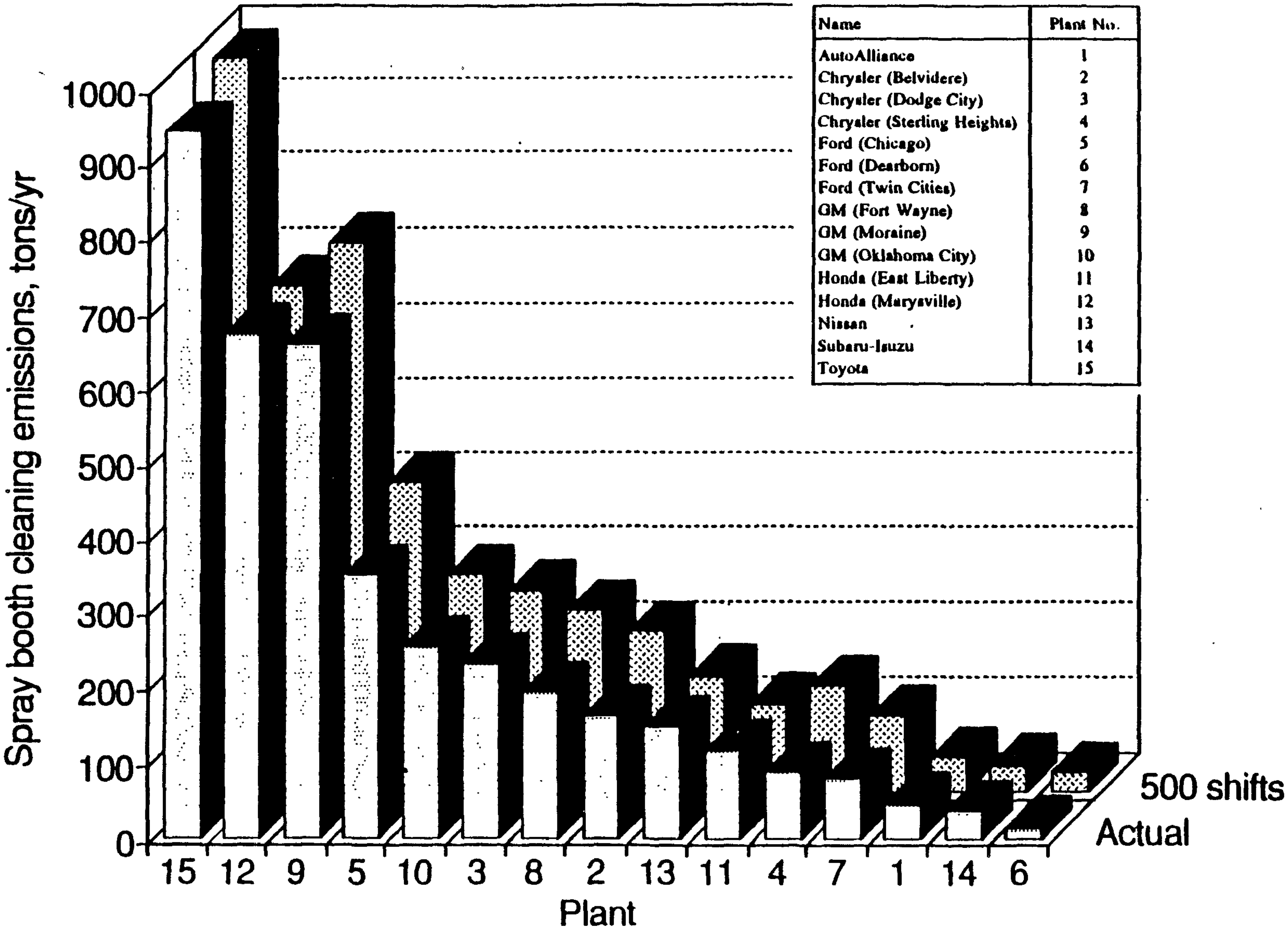


Figure 6-2. Reported VOC emissions from spray booth cleaning relative to plantwide permitted VOC emission levels in 1991.



Name	Plant No.
AutoAlliance	1
Chrysler (Belvidere)	2
Chrysler (Dodge City)	3
Chrysler (Sterling Heights)	4
Ford (Chicago)	5
Ford (Dearborn)	6
Ford (Twin Cities)	7
GM (Fort Wayne)	8
GM (Moraine)	9
GM (Oklahoma City)	10
Honda (East Liberty)	11
Honda (Marysville)	12
Nissan	13
Subaru-Isuzu	14
Toyota	15

Figure 6-3. Comparison of reported 1991 VOC emissions from spray booth cleaning with emissions normalized to 500 operating shifts.

At Plant 9, over 500 tons/yr (450 Mg/yr) of VOC emissions are from cleaning robots and related equipment. It is likely that this high level results from spraying solvent on the robots 4 times per shift, while most other plants wipe the equipment. This plant also sprays solvent to clean walls, windows, and some paint spray equipment tips. It also is one of only two plants to use solvent for cleaning floor grates, even though it is reported as only "touch-up" cleaning.

Plant 12 has the largest production and greatest number of booths (over twice the average) of the plants studied; this may contribute to the higher emissions. This plant does clean windows in 14 booths by spraying with solvent and wiping. The unprotected portions of robots and robots which cannot be covered are cleaned by wiping with solvent, as are the walls in the wax application and repair booths. Furthermore, this plant is one of the plants that uses solvent for cleaning personnel protective equipment and is one of two plants in which personnel clean their hands with solvent.

Although Plant 15 uses peelable coatings on the walls, the procedures the plant follows calls for wiping these coated walls on a daily or as-needed basis. Furthermore, the plant does not use robot covers, and wiping with solvent is the primary technique used for cleaning robots. Also the operators at this plant clean their hands and personal protective equipment with solvent; only one other plant also reported using solvent for this purpose. Plant personnel also indicated that they clean frequently and extensively as a result of the very high standard for cleanliness in their booths. Notably, this plant also has nearly twice the average number of booths.

At the other end of the spectrum, Plants 1, 6, and 14 have low emissions. One reason is because they use little or no solvent for cleaning booth walls. Also, they wipe solvent only on uncovered sections of robots and related equipment; in some booths the covers are extensive enough that no solvent is needed.

6.3.2 Qualitative Comparison of Emission Factors

Emission factors are often based on parameters such as the production rate or the unit of raw material consumed. In this study, relationships were examined between annual VOC emissions from spray booth cleaning and each of three annual production rate parameters: vehicles produced, unit vehicle surface area coated, and total vehicle surface area coated. The "unit" area is the actual surface area of the vehicle and all parts that receive at least one coat. The "total" area equals the unit area times the number of coats applied. For example, a vehicle may have a unit area of 200 ft^2 (19 m^2). Assuming the entire vehicle receives a basecoat, 25 percent is coated with black wax, 75 percent receives a clearcoat, and 10 percent of the coated area is repaired or receives final touchup, the "total" area would be 420 ft^2 (39 m^2). Table 6-3 summarizes the emissions, number of vehicles, area painted, and the resulting emission factors. Some qualitative observations are discussed below.

Figure 6-4 shows emissions vs. vehicle production rate. These data are widely scattered. In addition to variations in cleaning procedures, it is likely that this scatter is due to variations in such parameters as booth design and size, vehicle size and design, paint application procedures, and types of paint. The emission factors based on these data are shown in Figure 6-5. Except for the factors for plants 9 and 15, which are much higher than the others, all the factors fall within the range of .3 to 4 lb/vehicle (0.1 to 2 kg/vehicle).

Figure 6-6 shows emissions vs. the total vehicle surface area coated. As with Figure 6-4, these data also show scatter. The reasons for the scatter are the same as those given above for Figure 6-4. In addition, for Figure 6-6, there is uncertainty about the accuracy of the reported surface areas coated. For example, Plant 10 reported a total surface area so much higher than the others that it appears erroneous, and the ratio of total to unit surface areas vary over an unexpectedly wide range (1.1 to 4.7) for the four plants that provided both values.

TABLE 6-3a. SUMMARY OF EMISSION FACTORS[a] (English Units)

Plant	Ref.	Total emissions, tons/yr	Vehicles made in 1991	Emission factor, lb/vehicle	Total coated surface area				Unit coated surface area			Ratio of total to unit coated areas
					ft^2/shift	Shifts per year	$10^6 ft^2$/yr	Emission factor, tons/$10^6 ft^2$	ft^2 vehicle	$10^6 ft^2$/yr	Emission factor, tons/$10^6 ft^2$	
AutoAlliance	1	45	167,900	0.54	[a]	500			334	56.1	0.8	
Chrysler (Belvidere)	2	160	178,087	1.80	124,840	380	47.4	3.4	240	42.7	3.7	1.1
Chrysler (Dodge City)	3	228	177,134	2.57	402,458[b]	430	173	1.3				
Chrysler (Sterling Heights)	4	86	137,842	1.25	180,363	310	55.9	1.5	195	26.9	3.2	2.1
Ford (Chicago)	5	347	218,328	3.18	165,440	420	69.5	5.0				
Ford (Dearborn)	6	14	81,563	0.34	425,180	270	115	0.1				
Ford (Twin Cities)	7	78	125,275	1.41	194,710	390	75.9	1.2				
GM (Fort Wayne)	8	193	170,501	2.26	354,909	404	143	1.3				
GM (Moraine)	9	>657	178,520	7.36	356,612[c]	450	160	4.1				
GM (Oklahoma City)	10	251	228,925	2.19	1,927,550	440	848	0.3				
Honda (East Liberty)	11	114	94,222	2.54	[d]	500						
Honda (Marysville)	12	671	356,967	3.76	350,561[c]	500	175	3.8				
Nissan	13	146	262,000	1.12	[a]	480						
Subaru-Isuzu	14	35	116,297	0.60	227,200	490	111	0.3	205[e]	23.8	1.5	4.7
Toyota	15	940	187,951	10.0	581,529	480	279	3.4	1,028	193	4.9	1.4

[a]Except where noted, blanks signify no data provided by the plant.
[b]Surface areas from two repair areas not accounted for.
[c]Value shown is midpoint of the range reported by the plant.
[d]Claimed confidential.
[e]Weighted average of unit coated areas for trucks and cars.

TABLE 6-3b. SUMMARY OF EMISSION FACTORS[a] (Metric Units)

Plant	Ref.	Total emissions, Mg/yr	Vehicles made in 1991	Total coated surface area					Unit coated surface area			Ratio of total to unit coated areas
				kg/vehicle	m^2/shift	Shifts per year	10^6 m^2/yr	Emission factor, Mg/10^6 m^2	m^2 vehicle	10^6 m^2/yr	Emission factor, Mg/10^6 m^2	
AutoAlliance	1	41	167,900	0.24	a	500			31.0	5.2	7.8	
Chrysler (Belvidere)	2	145	178,087	0.82	11,598	380	4.4	33	22.3	4.0	37	1.1
Chrysler (Dodge City)	3	207	177,134	1.17	37,390[b]	430	16.1	13				
Chrysler (Sterling Heights)	4	78	137,842	0.57	16,756	310	5.2	15	18.1	2.5	31	2.1
Ford (Chicago)	5	315	218,328	1.4	15,370	420	6.5	49				
Ford (Dearborn)	6	13	81,563	0.16	39,501	270	10.7	1.2				
Ford (Twin Cities)	7	71	125,275	.57	18,089	390	7.1	11				
GM (Fort Wayne)	8	175	170,501	1.03	32,972	404	13.3	13				
GM (Moraine)	9	>596	178,520	3.34	33,130[c]	450	14.9	40				
GM (Oklahoma City)	10	228	228,925	1.0	179,075	440	78.8	2.9				
Honda (East Liberty)	11	104	94,222	1.f6	d	500						
Honda (Marysville)	12	609	356,967	1.7	32,568[c]	500	16.3	37				
Nissan	13	133	262,000	0.51	a	480						
Subaru-Isuzu	14	32	116,297	0.27	21,108	490	10.3	3.1	19.0[e]	2.2	14	4.7
Toyota	15	850	187,951	4.5	54,026	480	25.9	33	95.5	17.9	48	1.4

[a]Except where noted, blanks signify no data provided by the plant.
[b]Surface areas from two repair areas not accounted for.
[c]Value shown is midpoint of the range reported by the plant.
[d]Claimed confidential.
[e]Weighted average of unit coated areas for trucks and cars.

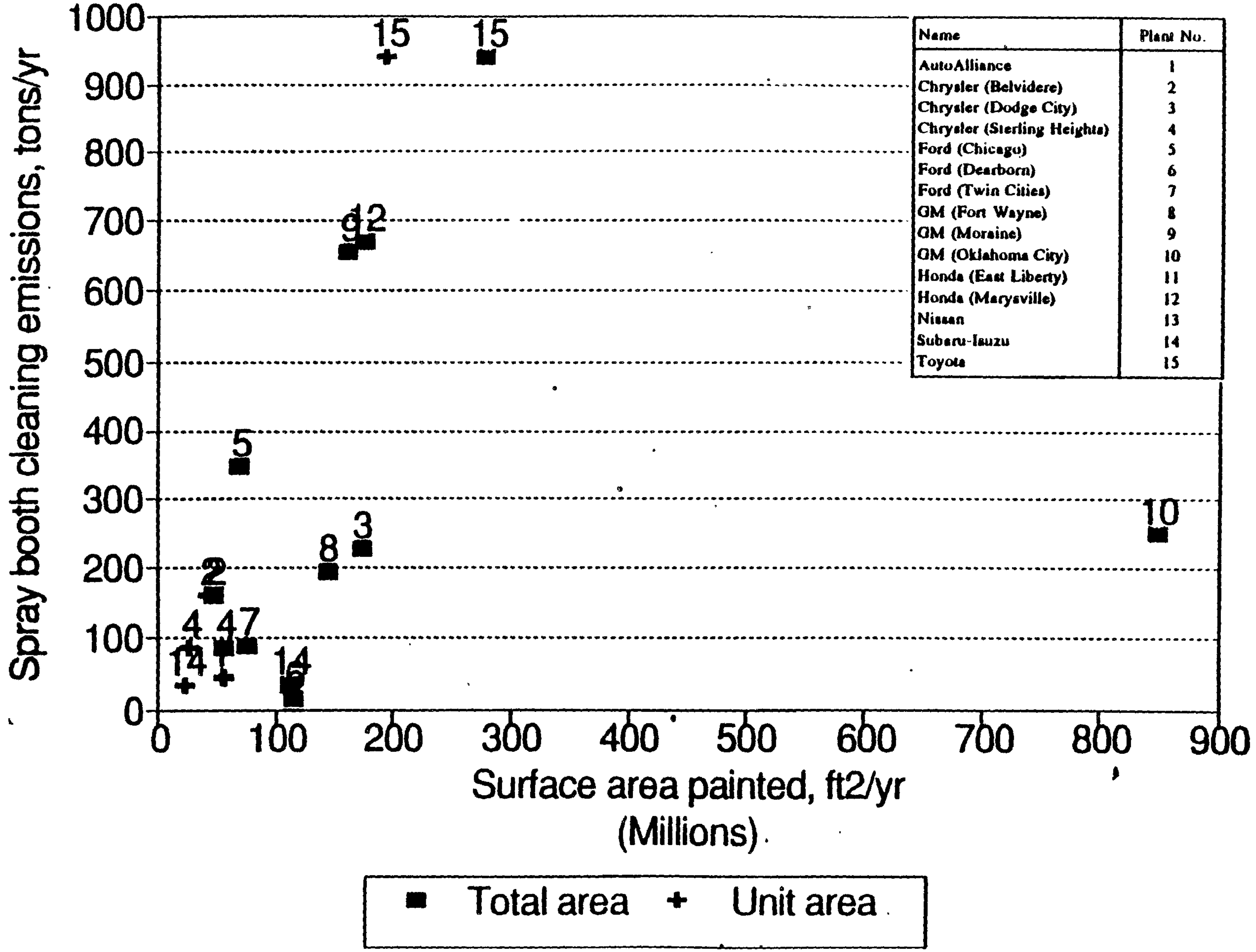


Figure 6-4. Spray booth emissions versus total vehicle and part surface area painted in 1991.

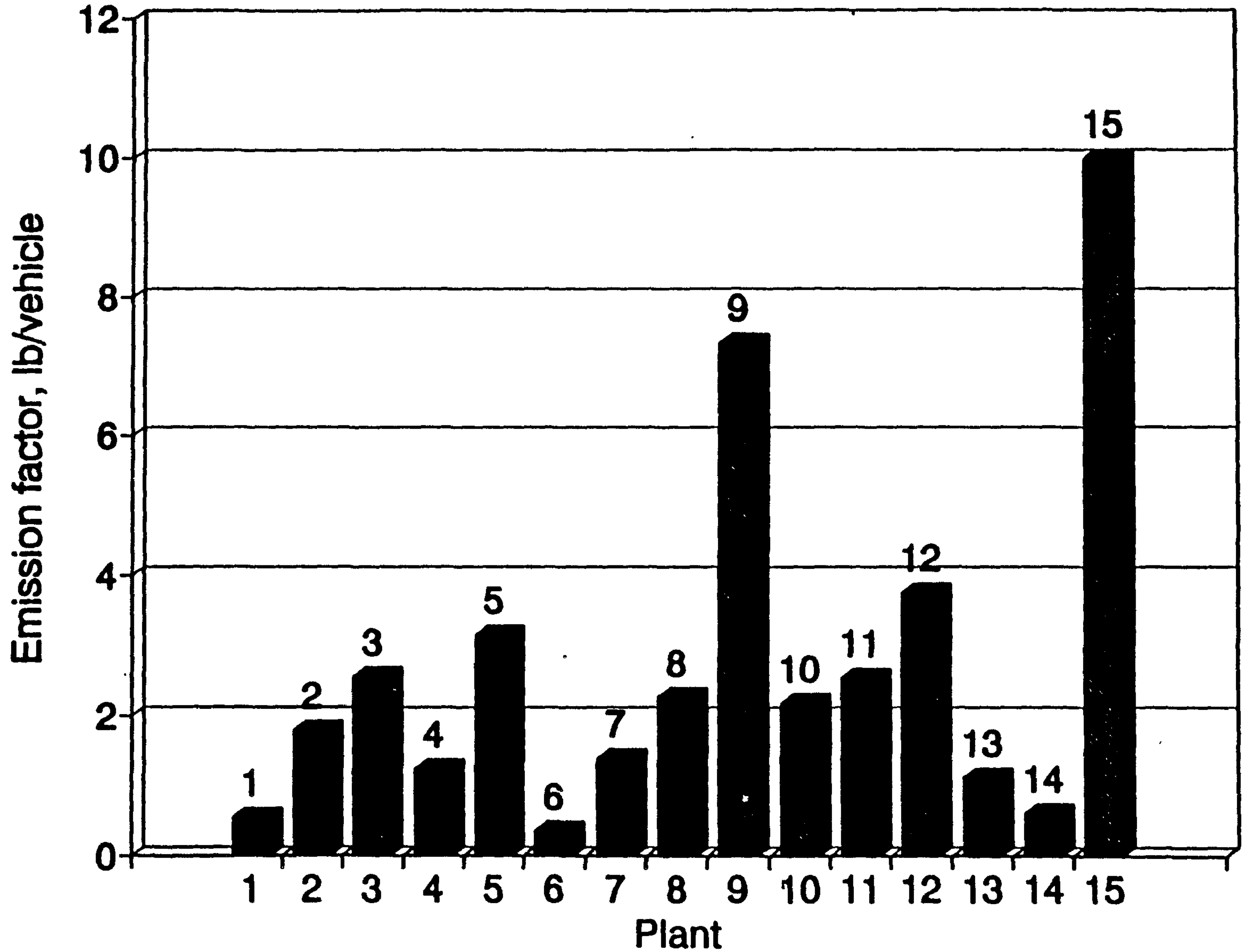


Figure 6-5. Spray booth emission factors based on number of vehicles produced (1991 data).

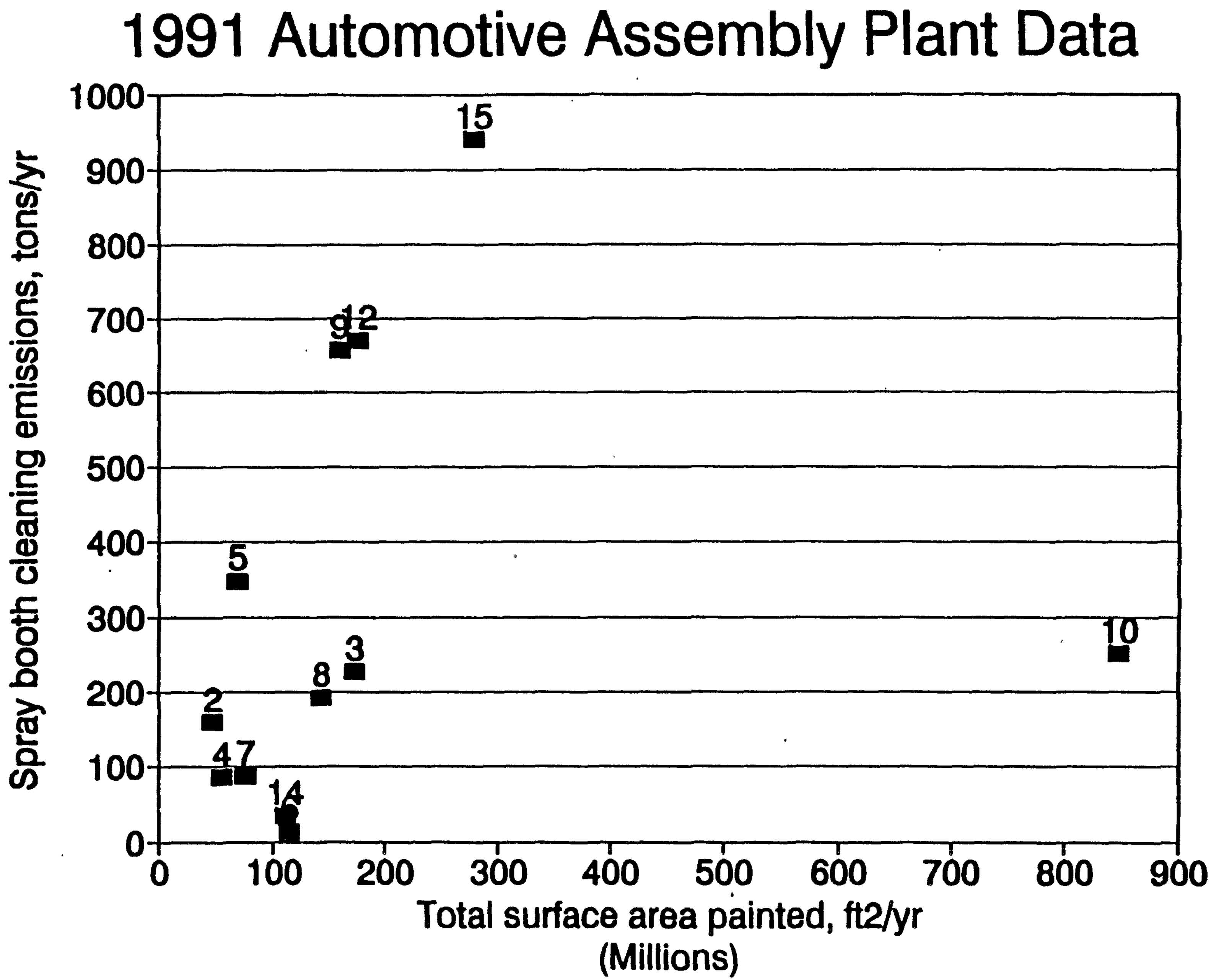


Figure 6-6. Spray booth emissions versus total vehicle surface area painted (1991 data).

Interestingly, the data shown in Figure 6-6 appear to fall into three zones. The upper zone includes Plants 2, 5, 9, 12, and 15; these plants have emission factors between 3.5 and 5.0 tons/million ft^2 (33 to 49 $Mg/10^6\ m^2$). The middle zone includes Plants 3, 4, 7, and 8; these plants have emission factors of between 1.0 and 1.5 tons/million ft^2 (11 to 15 $Mg/10^6\ m^2$). The lowest zone includes Plants 6 and 14, which have lower emission factors in the range of only 0.1 to 0.3 tons/million ft^2 (1 to 3 $Mg/10^6 m^2$). The emission factors are shown more clearly in Figure 6-7. More detailed information is needed to understand what caused these results.

These three zones of emission factors are similar to the groupings of plants with high, intermediate, and low emissions described in Section 6.3.1. Two exceptions are Plants 2 and 5 which have high emission factors, but rank in the intermediate range of total emissions. The reasons for the differences for these two plants are speculative. One possible explanation for Plant 5 is that, like Plant 9, robots and related equipment were cleaned by being sprayed with solvent 4 times/shift. This practice leads to high emissions. However, Plant 5 had much lower emissions than Plant 9, possibly because the vehicle surface area coated, and thus the amount of overspray to be cleaned, was significantly lower than that for Plant 9. Also, cleaning may have been performed less frequently at Plant 5.

A more detailed evaluation might result in development of different emission factors for various booth designs. However, emission factors based upon the surface area cleaned might be more useful. For example, an emission factor for wall cleaning might be based on the amount of solvent used and the wall surface area cleaned. Another emission factor might be based on the number of robots cleaned and the amount of solvent used to clean them. The necessary data for such emission factors were not collected during this study, and these types of data are not believed to be readily available.

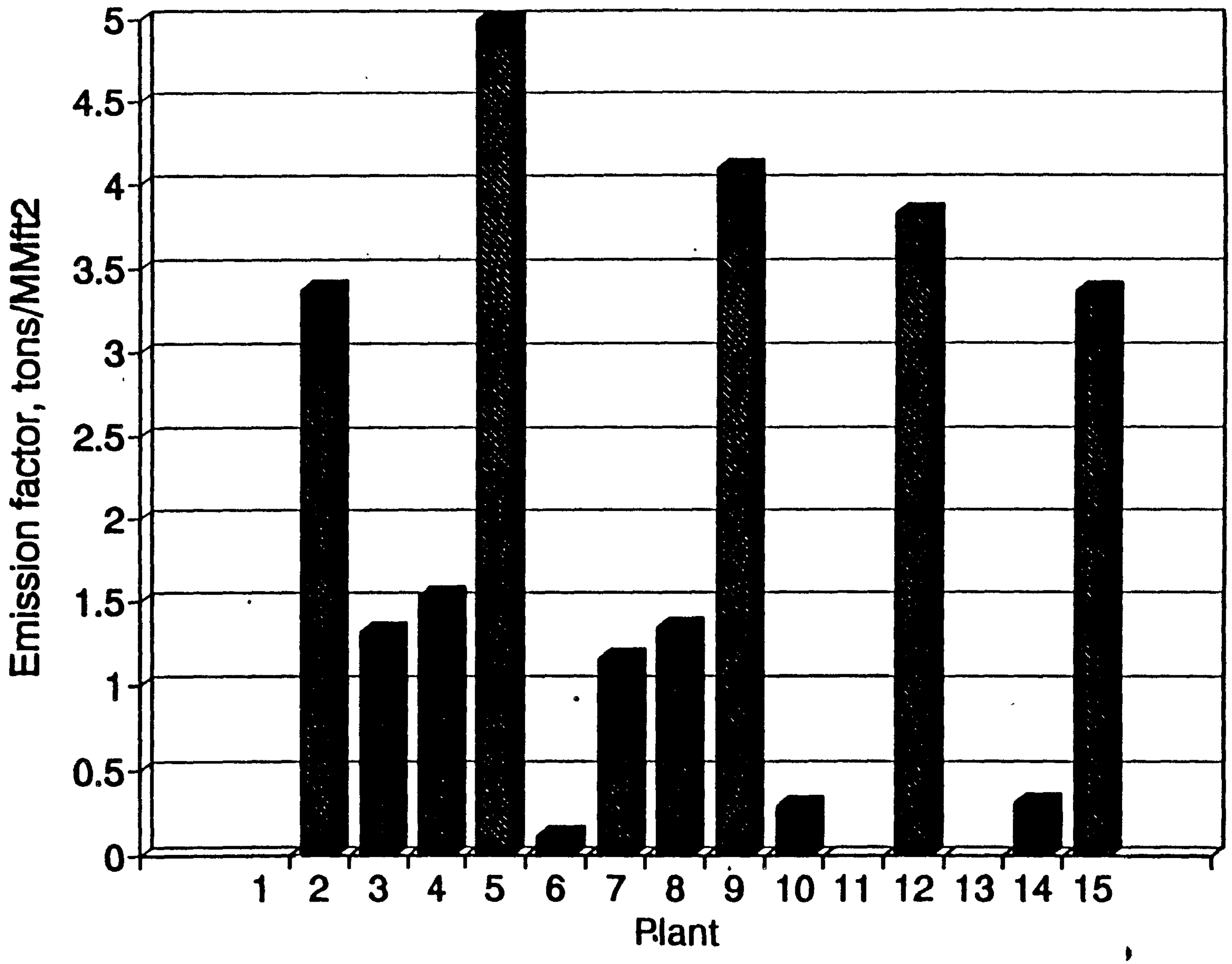


Figure 6-7. Spray booth emission factors based on total vehicle surface area painted (1991 data).

6.4 REFERENCES FOR SECTION 6

1. Response to Section 114 Information Request for AutoAlliance International, Inc., Flat Rock, MI. August 21, 1992.

2. Response to Section 114 Information Request for Chrysler Corporation, Belvidere, IL. August 1, 1992.

3. Response to Section 114 Information Request for Chrysler Corporation, Dodge City, MI. August 14, 1992.

4. Response to Section 114 Information Request for Chrysler Corporation, Sterling Heights, MI. August 14, 1992.

5. Response to Section 114 Information Request for Ford Motor Company, Chicago, IL. August 14, 1992.

6. Response to Section 114 Information Request for Ford Motor Company, Dearborn, MI. August 17, 1992.

7. Response to Section 114 Information Request for Ford Motor Company, Twin Cities, MN. August 17, 1992.

8. Response to Section 114 Information Request for General Motors Corporation, Fort Wayne, IN. August 14, 1992.

9. Response to Section 114 Information Request for General Motors Corporation, Moraine, OH. August 14, 1992.

10. Response to Section 114 Information Request for General Motors Corporation, Oklahoma City, OK. August 14, 1993.

11. Response to Section 114 Information Request for Honda of America Manufacturing, Inc., East Liberty, OH. August 12, 1992.

12. Response to Section 114 Information Request for Honda of America Manufacturing, Inc., Marysville, OH. October 29, 1992.

13. Response to Section 114 Information Request for Nissan Motor Manufacturing Corporation, USA, Smyrna, TN. September 28, 1992.

14. Response to Section 114 Information Request for Subaru-Isuzu Auto Incorporated, Lafayette, IN. September 15, 1992.

15. Response to Section 114 Information Request for Toyota Motor Manufacturing, USA, Inc., Georgetown, KY.

7.0 ALTERNATIVE CLEANING PRACTICES IN USE AT SURVEYED PLANTS

This section describes the types of alternative cleaning practices used at the 15 plants in 1991. After an overview, separate sections discuss the alternatives for each of the seven booth components. Each section presents the types of alternatives used; the types of booths in which they are used; and advantages, limitations, and solvent usage and VOC emission reductions that plants reported for some practices. Also presented are sections on alternative cleaning practices that were applied to multiple components and alternatives that were tried and rejected. Most of these practices are aimed at source reduction and are, therefore, pollution prevention practices.

7.1 OVERVIEW

Table 7-1 lists all of the alternatives that were reported by the 15 plants. It shows that specific cleaning practices within one or more of the five categories of alternatives were used for cleaning each of the seven booth components. The greatest variety of alternatives were used for wall cleaning, and the fewest for cleaning spray equipment tips. When two or more plants reported using a particular alternative, the number of plants is shown in parentheses. High-pressure water blasting for grates was the most common alternative. Other prevalent alternatives were robot covers, tacky and peelable coatings for walls and grates, and plastic sheeting for walls. In many cases, an alternative was used in only certain types of booths.

The following sections show that one or more plants have eliminated the use of cleaning solvent for each booth component, except spray tips. Additional information is needed to determine the reasons why some plants have successfully implemented

TABLE 7-1. TYPES OF ALTERNATIVE PRACTICES USED FOR CLEANING BOOTH COMPONENTS[1-15]

Booth component	Mechanical methods	Masking agent	Covers	Water-based or low VOC cleaners	Change of work practices
1. Walls	-- Scrape (3) -- Use low to high-pressure water to remove tacky coating (4) -- Water blast in wax booths (2) -- Scrape peelcoat -- Scrape vaseline -- Wipe walls in sealer and deadener booths with dry rags -- Add low VOC cleaner to water/steam blast to remove tacky coating -- Use nonatomizing sprayer along with bucket of solvent and brush	-- Tacky coatings (5) -- Peelable coating (5) -- Vaseline	-- Plastic sheeting (6) -- Stretch wrap -- Visqueen™ covers on areas where paint overspray is heavy -- White paper with wax on one side -- Heavy kraft or other types of paper -- Aluminum foil	-- Use a more viscous solvent so less is applied -- Low VOC cleaners (2) -- Water	-- Switch from continuous solvent spray over entire wall to spray only high on the wall followed by scrubbing the entire wall -- Reduce frequency of cleaning with solvent from 5 times a week to 2 times a week
2. Windows	-- Scrape with razor blade or putty knife (4) -- Use moderate or high-pressure water blasting to remove tacky coating (3) -- High-pressure steam -- Hot water blast -- High-pressure water blasting	-- Tacky coating (3)	-- Plastic cling film	-- Low VOC cleaners (4) -- Water-based cleaner -- Water (5)	-- Switch from spraying solvent on the window to spraying on rags before wiping -- Reduce frequency of cleaning with solvent from 5 times a week to 2 times a week
3. Grates	-- High-pressure water blasting, often directly, sometimes to remove tacky coating (15) -- Remove for incineration -- Remove for paint stripping in hot fluidized sand bed	-- Tacky coating (5)	-- Roofing felt (tar paper)	-- Caustic soda bath; sometimes, if not always, hot (4) -- Dip grates from wax booths in low VOC dewaxing agent	

TABLE 7-1. (continued)

Booth component	Mechanical methods	Masking agent	Covers	Water-based or low VOC cleaners	Change of work practices
4. Floors	-- Scrape -- Use steam injector to apply low VOC cleaner -- Walk behind/riding scrubbers		-- Tar paper (5) -- Plastic sheeting (3) -- One-sided, fire-proof aluminum foil (2) -- Kraft paper -- Cardboard -- Chipboard -- Soapy-water saturated carpeting	-- Low VOC cleaner (2) -- Non-VOC cleaner (2)	
5. Robots and related equipment	-- Scrape certain areas -- Wipe with dry rags -- Hot water blasting	-- Grease some components (2) -- Tacky coating for some cabinetry	-- Robot covers; usually Tyvex or cloth (10) -- Cover reciprocating sprayer arms, and possibly other parts, with aluminum foil (2) -- Plastic (2) -- Paint line hoses wrapped in plastic -- Hoses covered with masking tape -- Trash bag under robot sock	-- Water	-- Wiping instead of spraying solvent -- Smaller tips on solvent spray guns
6. Spray equipment tips	-- Ultrasonic cleaner			-- Water (2)	-- Replacement
7. Fixtures	-- High-pressure water blasting to clean conveyors and car body carriers -- Scrape greased areas -- Use copper scraper on areas coated with tacky coating -- Water blast greased areas -- Use Berylco™ scraper	-- Grease conveyor structure to cut water blasting time -- Peelable coating -- Grease center track drive cover and remove by scraping -- Use tacky coating on center track drive covers -- Grease stack	-- Tape on conveyors -- Aluminum foil -- Plastic sheeting (2)	-- Water soluble, low VOC stripper applied to center track drive covers; removed by scraping and rinsing with water -- Low VOC cleaners	

Possible factors to examine are the cost and labor requirements relative to using solvent; booth design parameters such as the wall construction material, the distance of the wall from paint application equipment; the type of paint application equipment; and the type of paint.

7.2 ALTERNATIVE CLEANING PRACTICES FOR WALLS

A wide variety of alternative cleaning practices were used for walls. The most common were peelable and tacky coatings and plastic sheeting covers. Lesser used and more specialized practices included manual scraping, paper and aluminum foil coverings, water blasting (often in conjunction with tacky coatings), Vaseline™ masking, and wiping with water and rags.

Plants that still use solvents have reduced usage and emissions by reducing the frequency of cleaning, switching to low VOC or more viscous solvents, and reducing spraying in favor of increased manual scrubbing.

7.2.1 Alternatives by Booth Type

Table 7-2 shows the wall cleaning practices used in different types of booths at the 15 plants. Interestingly, 20 percent of the plants (3 of 15) used no solvent for wall cleaning in any of the booths and, overall, at least 40 percent of each type of booth was cleaned without solvent.

7.2.1.1 Topcoat and Tutone Booths. The primary alternatives used in the topcoat booths were tacky and peelable coatings. Of the nine plants using these alternatives, six used no solvent, one sprayed solvent on the coating occasionally to remove paint that penetrated the coating, and two wiped the peelable coating every day with solvent and a rag.[2,4,6,8,10,12-15] One plant switched from spraying solvent on the peelable coating with an air-atomized gun and sloshing solvent out of buckets to scrubbing with brushes dipped in a bucket of solvent.[4]

One plant used Visqueen™ coverings (a polyethylene film) on parts of the walls and scrubbed the uncovered parts with solvent and a brush.[1] Another plant wiped the walls in the basecoat booths with water-soaked rags; this plant used waterborne

TABLE 7-2. CLEANING PRACTICES FOR WALLS

Ref.	Type of booth[a]								Comments
	Topcoat (and Tutone for some plants)	Repair	Primer	Antichip	Bumper and fascia	Underbody (blackout and deadener)	Wax	Miscellaneous	
1	Visqueen™ covering to some areas and solvent applied with brush and scrubbed in others		Visqueen™ covering to some areas and solvent applied with brush and scrubbed in others		Plastic sheeting	Solvent applied from squeeze bottle and wiped			
2	Tacky coating; remove with water	Tacking coating; remove with water				Plastic sheeting			Glass walls in topcoat and repair booths
3	Spray with solvent and scrub daily	Spray with solvent and scrub daily		Spray with solvent and scrub daily		Scrape			Stainless steel walls in topcoat, antichip, Tutone, and repair booths
4	Peelable coating; wipe with solvent daily	Peelable coating; wipe with solvent daily (high bake booth) Wipe with solvent (low bake booth)		Part of Tutone booth (peelable coating; wipe with solvent daily)		Plastic film			Galvanized walls in Tutone, topcoat, and high-bake repair booths. Stainless steel walls in low-bake repair booth
5	Scrub with brush and low VOC cleaner	N/A	Scrub with abrasive pads dipped in container of low VOC cleaner				N/A	N/A	Stainless steel walls
6	Tacky coating; wash off with water weekly	Tacky coating; wash off with water weekly	Tacky coating; wash off with water and low VOC[c] cleaner daily		N/A			N/A	Cleaning practices for touchup booth were not reported
7	Spray with solvent and scrub with brush twice a week	Spray with solvent and scrub with brush twice a week	Spray with solvent and scrub with brush twice a week				Water blasting	Scrape with razor blades and glass cleaner in touchup booth	Glass walls in primer, topcoat, and repair booths.

TABLE 7-2. (continued)

Ref.	Type of booth[a]								Comments
	Topcoat (and Tutone for some plants)	Repair	Primer	Antichip	Bumper and fascia	Underbody (blackout and deadener)	Wax	Miscellaneous	
8	Tacky coating; remove with high pressure water. Spray solvent in areas where paint penetrated the coating, scrub, and rinse with water	High pressure steam		Tacky coating; remove with high pressure water				Tacky coating; remove with high pressure steam in the wheel spray booth	
9	Spray with solvent and rinse with water once a week	Spray with solvent and rinse with water once a week		Spray with solvent and rinse with water once a week		Spray with solvent and rinse with water once a week		Plastic sheeting for fuel tank blackout booth	Glass walls in all booths
10	Tacky coating; remove with water twice a week	Tacky coating; remove with water twice a week	Tacky coating; remove with water twice a week		N/A			N/A	Plant has two repair booths; cleaning practice reported for only one. Cleaning practice for steering column booth was not reported
11	Wipe with water-soaked rags in basecoat booths Plastic sheeting; wipe with solvent daily in clearcoat booths	Plastic sheeting; wipe with solvent daily	Plastic sheeting			Plastic sheeting for part of the walls; wipe uncovered areas with rag and solvent	Plastic sheeting; wipe with solvent and rag once a week in cavity wax booth Spray solvent and wipe off in black wax booth	Wipe with water-soaked rags for final touchup booth Wipe with dry rags in sealer booth	Waterborne paint used in basecoat booth

TABLE 7-2. (continued)

Ref.	Type of booth[a]								Comments
	Topcoat (and Tutone for some plants)	Repair	Primer	Antichip	Bumper and fascia	Underbody (blackout and deadener)	Wax	Miscellaneous	
12	Peelcoat	Peelcoat for vehicle body repair booths	Peelcoat		Peelcoat	Wipe with dry rags	Wipe with solvent and rags	Peelcoat in touchup booth Wipe with dry rags in sealer booth Aluminum foil up to 6 ft in parts repair booths; wipe uncovered areas with rag and solvent	
13	Peelcoat	Peelcoat	Peelcoat		Stretch wrap; wipe with rag and small amount of solvent once a week			Vaseline used in fuel tank booth	
14	Peelcoat	Peelcoat	Peelcoat		Peelcoat	Peelcoat	Peelcoat		
15	Peelcoat; occasionally wipe heavy overspray with solvent	Wipe with solvent and rag	Peelcoat; occasionally wipe heavy overspray with solvent	Partially cover with kraft paper, scrape and wipe with solvent	Paper	Kraft paper, scrape, and wipe with solvent	Wipe with solvent (interior wax booths) Water blast (exterior wax booths)	Cover with paper in plastic parts booths and fuel tank booth Peelcoat for engine primer booth	
Percentage of plants with no VOC emissions	40	46	50	33	80	56	40	86	

N/A = Plant did not specify cleaning practice for this booth.
[a]Blanks signify the plant does not have a booth for this function.

basecoat. This plant covered the walls in the clearcoat booths with plastic, which was wiped daily with solvent and a rag.[11]

Three plants relied on solvent to clean the walls, and two of these plants reported practices to reduce solvent usage. One switched to a more viscous solvent, and replaced the atomizing solvent spray gun with a nonatomizing model.[3] The plant did not explain the benefit of a viscous solvent, but it may adhere to the surface longer than other solvents, thus requiring less to be applied. The other plant changed from spraying solvent over the entire wall to spraying only the upper portion of the wall and manually scrubbing the lower portions with a brush dipped in a bucket of solvent. This plant also reduced the frequency from 5 times a week to 2 times a week.[7]

Two of the plants that relied on solvent had glass walls, and the third had walls made of stainless steel.[3,7,9] It is not known which alternatives are compatible with which construction materials; most of the other plants did not report the wall construction materials.

7.2.1.2 Repair Booths. Wall cleaning practices for repair booths were similar to those for topcoat booths. Seven plants used tacky or peelable coatings, six of which used no solvent, and one wiped with solvent every day.[2,4,6,10,13,14] One plant used high-pressure steam with no solvent, and another used plastic sheeting that was wiped with solvent daily.[8,11] Four plants sprayed or wiped solvent directly on the wall.[3,7,9,15] One plant did not specify the cleaning practices, and another did not have a separate repair booth.[1,5]

7.2.1.3 Primer and Antichip Booths. Fourteen plants applied primer, antichip, or both in spray booths (10 applied primer and 12 applied antichip coatings); only one plant had no primer or antichip spray booth. Seven plants applied both coatings in the same booth. Overall, eight plants used no solvent in primer and antichip booths, although two had VOC emissions because they used low VOC cleaners.[5,6,8,10-14]

At three of the plants with dual-purpose booths, walls were coated with peelcoat or tacky coating, and no solvent was used.[10,13,14] At the other four plants with dual purpose booths, one coated the walls with tacky coating and removed it with a low-VOC solvent in conjunction with water blasting; one used Visqueen™ coverings on part of the walls and wiped the other parts with solvent; one dipped abrasive pads in a low VOC cleaner and then scrubbed with the pads, and one sprayed solvent on and scrubbed with brushes.[1,5-7]

Three plants had separate primer booths. One used plastic sheeting, and two used peelcoat. One of the plants using peelcoat occasionally wiped areas that received heavy overspray with solvent.[15] The other two used no solvent.[11,12]

Four plants applied antichip in separate booths. One applied a tacky coating to the walls and removed it with high-pressure water.[8] One plant partially covered the walls with kraft paper and removed the residue by scraping and wiping with solvent and a rag.[5] Two sprayed solvent on the walls (daily at one plant and weekly at the other).[3,9]

One plant applied antichip coatings in the tutone booth. As described above, walls in this booth were masked with peelable coating and wiped with solvent daily.[4]

7.2.1.4 Bumpers and Fascia Booths. Seven plants had one or more booths in which coatings were applied to bumpers and fascia. All five of the plants that specified their cleaning practices used alternatives. Two used peelcoats, one used paper, one used plastic sheeting, and one used plastic stretch wrap. The stretch wrap was wiped with a rag and a small amount of solvent once a week.[13] The other four plants used no solvent.[1,12,14,15]

7.2.1.5 Underbody (Blackout/Deadener) Booths. Nine plants had booths in which underbody coatings were applied. Five used alternative cleaning practices that involved no solvent, two of which used plastic sheeting, one used a peelcoat, one manually scraped the walls, and one wiped the walls with dry rags.[2-4,12,14]

The other four plants used a variety of practices. One covered the walls with kraft paper and removed the residue by scraping and wiping with solvent.[15] One used plastic to cover part of the walls and wiped the uncovered parts with solvent.[11] One sprayed solvent from a squeeze bottle and wiped off the residue.[1] One sprayed solvent on the walls and rinsed the residue off with water.[9]

7.2.1.6 Wax Booths. Five plants described cleaning practices for walls in seven wax application booths. In three of the seven, alternatives were used with no solvent; two used water blasting, and one used a peelcoat.[7,14,15] One plant used plastic sheeting on some walls and wiped the plastic with solvent once a week; solvent was sprayed on other walls and wiped off.[11] Two plants wiped solvent-laden rags directly on the walls.[12,15]

7.2.1.7 Miscellaneous Booths. Seven plants identified a variety of cleaning practices used for several miscellaneous booths. The cleaning practices included the use of plastic sheeting, paper, Vaseline™, peelcoat, tacky coating, scraping with razor blades, and wiping with water-soaked or dry rags. Six use no solvent, and one used no solvent in some booths. The booths were used for a variety of purposes, including applying (1) paint to garnish and mirror covers, plastic parts, and wheels, (2) antichip coatings to fuel tanks, (3) primer to engines, and (4) sealers. The final touchup booths at two plants were also included in this category.[7-9,11-13,15]

One plant with small parts repair booths used aluminum foil from the floor to a height of 6 feet and wiped uncovered areas with solvent.[12]

7.2.2 Advantages and Limitations of Alternatives

Peelable coatings are applied either by spraying or by using rollers and brushes. The quantity used and the coverage provided varies. They are removed after 3 to 6 weeks and are disposed of in 55-gal drums that are sent either to landfills or to be incinerated.[1,4,14,15] The advantages reported include the effectiveness of the coating in shielding the walls from overspray, a reduction in VOC emissions and the amount of waste generated during cleaning, and fast and easy application and removal.[1,4,14,15] One plant indicated that substituting peelable coating for plastic sheeting decreased labor costs by

50 percent.[14] No limitations were reported. One plant with galvanized walls indicated that peelable coatings have been used since plant startup to protect the walls; the actual cleaning practice is to wipe the peelable coating with solvent every day.[4]

Tacky coatings are mostly water-based, nonhazardous, and non-VOC (or very-low-VOC) materials that can be removed with water (either high- or low-pressure). The removed material is washed into the booth waterwash system, and the resulting waste is nonhazardous. The coatings are easy to apply and remove, and their use reduces the overall use of cleaning solvents. One plant cautioned that, because they are removed with water, tacky coatings cannot be applied in areas where water cannot be used (e.g., around the automated equipment).[10]

Plastic sheeting is inexpensive and is not affected (e.g., does not disintegrate) by paint overspray. It also can be used to cover those booth components for which specifically designed covers are unavailable or for which the use of specifically designed covers is impractical.[2,4,7,9,11,12] Advantages and limitations of other alternative cleaning practices for walls were not reported.

7.2.3 Reported Solvent Usage and VOC Emission Reductions

Table 7-3 shows the reported reductions for alternatives implemented by 7 plants.[2-4,6,7,11,12] These are the total reductions for all booths at the plants. The largest reductions were achieved by plants switching from spraying solvents to spraying more viscous solvents, increased manual scrubbing, and possibly to a tacky coating or plastic covering (these plants did not indicate the previous cleaning practice to which the alternative was compared).[2-4,11]

7.3 ALTERNATIVE CLEANING PRACTICES FOR GRATES

Grates were used in a variety of booths, and 12 of the plants implemented alternative cleaning practices that did not require the use of solvent regardless of the booth. As shown in Table 7-1, most of the alternatives were based on the use of either high-pressure water blasting or a caustic soda bath; some plants used both. Five plants also applied a tacky coating (or

TABLE 7-3. REPORTED REDUCTIONS OF ALTERNATIVES FOR WALLS

Alternative	Previous cleaning practice	Booths in which alternative is used	Solvent usage reduction, gal/yr[a] (l/yr)	Emission reduction[a] tons/yr (mg/yr)	Emission reduction[a] Percent	Ref.
1. Use viscous solvent and nonatomizing spray gun	Spray solvent with air-atomizing gun	Stoneguard/topcoat (2) Topcoat Topcoat repair (2)	55,000 (208,000)	187 (170)	N/A	3
2. Dip brushes in buckets of solvent and scrub with brush[b]	Spray solvent using air-atomized guns and slosh solvent from buckets[b]	Antichip Topcoat (2) Repair (2)	23,604 (89,340)	81.4 (73.8)	N/A	4
3. Coat with tacky coating and remove with low-pressure water	N/A	Color (2) Reprocessing	21,112[c] (79,900)	71[c] (64)	100	2
4. Cover with plastic	N/A	Sealer Deadener Surfacer Clearcoat Repair Wax (2) Touchup	6,820[d] (25,800)	23.7[d] (21.5)	N/A	11
5. Coat with peelcoat	N/A	Topcoat (4) Surfacer (2) Tutone Bumper (2) Repair (2)	5,720 (21,600)	20.8[e] (18.9)	N/A[f]	12
6. Coat with tacky coating and remove with high-pressure water	N/A	Primer/antichip Topcoat Repair	4,600 (17,400)	12.5 (11.3)	N/A[g]	6
7. Cover with polyethylene	None[h]	Blackout	1,812 (6,860)	1.4 (1.3)	100	4
8. Clean with solvent twice a week (no covers or masking)	Clean with solvent 5 times a week	Topcoat Topcoat repair	1,800 (6,800)	6.5 (5.9)[i]	N/A[j]	7

TABLE 7-3. (continued)

Alternative	Previous cleaning practice	Booths in which alternative is used	Solvent usage reduction, gal/yr[a] (l/yr)	Emission reduction[a]		Ref.
				tons/yr (mg/yr)	Percent	
9. Cover with white paper	None	Topcoat (4) Repair (2) Tutone Surfacer (2) Sealer (2) Deadener (2) Blackwax Bumper (2)	936 (3,540)	3.4[e] (3.1)	N/A[k]	12
10. Apply low VOC, caustic solution through steam hose to assist removal of peelcoat	N/A	Primer/antichip	800[l] (3,000)	2.2[l] (2.0)	N/A	6
11. Spray solvent only high on wall, manually scrub entire wall, and squeegee off the residue	Spray solvent over entire wall	Topcoat Topcoat repair	735 (2,780)	2.6[i] (2.4)	N/A	7

N/A = not available.
None = Method has not changed since plant startup.

[a]Except where noted, the reductions were reported by the plants.
[b]The plant has galvanized walls that have been covered with a tacky coating since plant startup; just the method of solvent cleaning has changed.
[c]Assumed to be primarily for wall cleaning, although an unspecified part of the reduction was from application of the coating to robot cabinetry.
[d]Assumed to be primarily for wall cleaning, although an unspecified part of the reduction was from covering the base of robots and conveyors.
[e]The plant did not report emissions reductions. This value was calculated based on the assumption that xylene usage was reduced, and no spent solvent was collected.
[f]The plant did not report the percentage reduction, but no solvent was used to clean the walls except in the repair booths.
[g]The plant did not report the percentage reduction, but no solvent was used to clean the walls in the topcoat and repair booths; the amount used in the primer booth was not reported.
[h]Reported reductions were based on estimates of how much solvent would be needed if polyethylene sheeting were not used.
[i]Reported valve is based on assumption that 100 percent evaporates, which may overestimate the reduction because another part of the response indicates collected spent solvent equals 50 percent of the amount used. Some of the collected solvent may have been from the wall cleaning.
[j]The plant did not report the percentage reduction. Assuming the solvent requirement for each cleaning was essentially unchanged, the reduction would be 60 percent.
[k]In the areas where the white paper was used, no solvent was needed. However, the amount of solvent used on other wall areas was not reported.
[l]The method is also used on the floor. The reduction applies to both wall and floor cleaning.

even tar paper for one booth at one plant) to ease removal with the water blasting. Some plants used water blasting on the grates in place, while others removed them for cleaning in a single location. Naturally, removal is essential for grates that are cleaned by dipping in a caustic soda bath.

One plant used a tacky coating on the grates in most booths (those where water blasting could not be used) and each night removed and transported them to an onsite "Blu-Surf" incinerator.[10] Another plant removed grates from some booths on an unspecified interval for paint stripping in a hot fluidized sand bed. This plant also removed grates from other booths for cleaning by "incineration" (may be the same hot fluidized sand system).[1] A third plant water blasted the grates in place once a week and, once a year, removed them for cleaning in a heat cleaning oven.[7]

Three plants used solvent along with alternatives. One performed daily touchup cleaning with solvent and used water blasting once a week.[9] The second applied a tacky coating that was removed by water blasting, but solvent was sprayed on areas where the paint overspray penetrated the coating.[8] The third dipped the grates from a wax application booth in a caustic solution that includes a low VOC cleaner.[15]

7.3.1 Advantages and Limitations of Alternatives

The plants described a variety of water blasting equipment, including lawn-mower-type units, rotary nozzles on wheels, spinning wand assemblies, and hand-held lances. Besides eliminating the use of solvent and the associated VOC emissions, the main reasons reported for using this equipment were its efficacy, speed, relative ease, and reduced waste generation (primarily relative to dipping in caustic solutions).[1,3,4,6-12,14,15] Some water blasting units were reportedly inexpensive and easy to use and maintain. One plant indicated that some equipment allows hot water to be used, which allows for a lower pressure and reduces operator fatigue.[8]

Several limitations of high-pressure water blasting were reported. One plant indicated that it cannot be used around electrostatic spray equipment because it will result in grounding problems.[9] Numerous plants indicated that it may splatter debris in unwanted areas, which one plant combated by draping plastic sheets over the walls and ceilings while cleaning the grates. Some plants indicated some areas of the booth are inaccessible to in-place cleaning (e.g., under the bell zones). One plant indicated applying tacky coating to the grates was time-consuming and labor intensive.[10] One plant tried to switch from caustic soda baths to water blasting but gave up primarily because the water blasting damaged the "wet pans," which in their booths lie closely beneath the grates.[2] One plant indicated the initial cost of the equipment is high. Although not a limitation, several plants reported the necessity of operator training to use the equipment.[6,8,12]

Caustic stripping tanks are steam heated, and the grates are loaded on racks or in baskets before lowering by crane into the tank. The cleaning is fast (but labor intensive to remove, load into the tank, and replace), relatively inexpensive, and often eliminates the use of cleaning solvents (one of the five plants with caustic tanks used a low VOC cleaner in the solution). The sludge from the caustic tanks is a hazardous waste.

One plant indicated incineration is not as messy as water blasting, but they have had problems with incinerator malfunctions.[10] Another plant reported incineration could not remove sealers from the grates.[1]

7.3.2 Reported Solvent Usage and VOC Emission Reductions

Table 7-4 shows the reported plantwide emission reductions for three of the plants using high-pressure water blasting to clean grates. One hundred percent reductions were achieved, but the total reductions were small relative to the remaining solvent usage at most of the plants.[1,4,6]

7.4 ALTERNATIVE CLEANING PRACTICES FOR FLOORS

Fourteen of the plants provided information about cleaning practices for floors. However, they did not all provide information on the same basis because the information request did not specify whether the responses were to address floor cleaning

TABLE 7-4. REPORTED REDUCTIONS OF ALTERNATIVES FOR GRATES[a]

Alternative	Previous cleaning practice	Booths in which alternative is used	Solvent usage reduction, gal/yr[b] (l/yr)	Emission reduction[b]		Ref.
				tons/yr (Mg/yr)	Percent	
1. High-pressure water blasting	Incineration	Stoneguard Primer Enamel (2) Tutone	2,450[c] (9,270)	7.9 (7.2)	100[d]	1
2. High-pressure water blasting	N/A	Primer/antichip Topcoat Repair	2,070 (7,830)	5.6 (5.1)	100	6
3. Cover with tacky coating (and roofing felt tar paper in one booth) and remove with high-pressure water blasting	None	Antichip Topcoat (2) Repair (2) Blackout	N/A	N/A	100[d]	4

N/A = not available.
None = The alternative cleaning practice has been used since plant startup.

[a]Most of the surveyed plants used water blasting to clean grates; these were the only ones to report reductions.
[b]Except where noted, all reductions were reported by the plants.
[c]The plant estimated the amount of solvent that would be needed if the alternative were not used; it is not the reduction relative to incineration.
[d]The plant reported no solvent was used to clean grates.

inside booths, outside (track-out), or both. Thus, two plants only described cleaning practices for floors outside booths, four described practices for floors inside, six described both, two did not identify the location, and one provided no data. Although not stated in any of the responses, when no data were provided for inside cleaning, it probably meant that the booth had no floors, only grates. Alternatively, when they provided no information about cleaning track-out from the booth, it simply may have been overlooked.

As shown in Table 7-1, about two-thirds of the alternatives involve the use of various covers. Seven of the plants used some solvent for cleaning.

Of the 10 plants that described cleaning practices for floors inside booths, 9 had at least one booth in which no solvent was used. They relied on covers made of chipboard, plastic, tar paper, cardboard, and kraft paper. These covers were used in three blackout booths as well as deadener, fuel tank, antichip, wheel repair, transit coating, small parts, and final touchup booths.[2-5,7,12-15] They were also used in a clean room at one plant.[11] Two of the plants used solvent for cleaning floors in certain booths: one wiped the floor in the cavity wax booth with a rag and mineral spirits, and the other spot cleaned the floors in the fascia booth with alcohol and a rag, followed by mopping with a non-VOC cleaner.[11,13]

Of the eight plants that reported cleaning practices for floors outside booths, only two resulted in no VOC emissions. One used carpeting saturated with a soapy-water solution, and the other covered some areas with a fireproof paper-backed foil and mopped uncovered areas with a non-VOC cleaner.[4,5] Of the other six plants, one covered parts of the floor with a fireproof, paper-backed foil and mopped uncovered areas with solvent or soap and water, one mopped with a low-VOC cleaner, two mopped with solvent, one used a low-VOC cleaner with both a walk-behind/riding scrubber and mopping, and one used a walk-behind/riding scrubber with solvent for open areas and mopping with solvent for less accessible areas.[2,3,7,8,10,13]

Two plants reported ways to reduce track-out. One custom-designed a shoe/boot cleaner, and the other required operators to change shoes when entering and leaving the booths.[7,14]

One plant indicated that floors were scraped, but it was not clear whether they were inside or outside booths.[1] Another plant indicated floors were mopped with solvent, but again it was not clear whether the floors were inside or outside the booths.[6]

7.4.1 Advantages and Limitations of Alternatives

One plant indicated the chipboard is inexpensive, stays in place (with tape), is sufficiently wear-resistant, and provides some cushion for walking comfort.[2] One plant reported tar paper is durable and holds debris well.[4] One plant indicated cardboard is inexpensive and its use eliminates the need to clean and buff the floor.[12] Three plants indicated the waste cover materials are nonhazardous.[4,12,14]

Although manual mopping of the floors is a common practice, it may not be feasible in some plants because scrubbing may damage the permanent masking film on the floor.[16]

One plant used a low-VOC cleaner with the powered walk behind/riding scrubber. The low-VOC cleaner could not be used with manual mopping because of the extensive scrubbing effort required.[7]

One plant tried and rejected an alternative that consisted of painting the floors adjacent to spray booths with acrylic paint. This cleaning practice was tested as a way to reduce manual mopping during the cleaning of track-out; the result was unsuccessful. Paint, grease, and sealer adhered to the surface, created a less aesthetic appearance, and was more difficult to clean.[10]

One plant tried an alternative low-VOC floor cleaner. Although it smelled better, it was rejected because it did not dry fast enough, created a safety hazard due to the slipperiness of the floor, did not clean as quickly, and compared with solvent, more of the alternative cleaner was needed to clean a given area.[3]

7.4.2 Reported Solvent Usage and VOC Emission Reductions

Table 7-5 shows reported reductions for five alternative cleaning practices at three plants.[4,7,11] The most significant reductions occurred when switching to alternatives that eliminated the use of solvent.[7] Only minor reductions were achieved by eliminating the use of low-VOC cleaners.[4]

7.5 ALTERNATIVE CLEANING PRACTICES FOR ROBOTS/EQUIPMENT

Thirteen plants used alternatives in conjunction with solvent to clean most robots and related equipment; two plants relied solely on spraying and wiping with solvent. Typically, part of the equipment was covered, and the remaining uncovered areas were wiped with rags and solvent. A few plants used tacky coatings or mechanical methods for certain surfaces. Except for the use of water on certain equipment surfaces in one booth at one plant, no water-based or low-VOC cleaners were used. One plant reported switching from spraying solvent to wiping (others probably have done the same thing but did not report it).[10]

As shown in Table 7-1, the most common alternative cleaning practice (reported by 10 plants) was the use of specialized, designed-to-fit robot covers for portions of the equipment.[1,3,6-8,11-15] Four plants reported the use of disposable Tyvek™ covers, one installed reusable nylon covers, one indicated reusable "lint-free" (which suggests some type of cloth) covers were used, and the other four did not describe the covers. The nylon covers were washed in solvent.[7] The "lint-free" covers were sent offsite for "chemical cleaning" and then returned.[8]

Seven of the plants implemented alternatives that eliminated the need for solvent in one or more booths, typically auxiliary booths. One plant reportedly avoided solvent use for cleaning spray equipment in the topcoat, primer/antichip, and two tone/repair booths by having used Tyvek™ covers since plant startup.[14] Three plants used robot covers to eliminate or avoid the use of solvents in bumper painting booths.[1,6,14] Two used only dry rags on equipment in sealer and deadener application booths.[11,12] At three plants, various covers were used without

TABLE 7-5. ALTERNATIVES FOR FLOORS

Alternative	Previous cleaning practice	Booths in which alternative is used	Solvent usage reduction, gal/yr[a] (l/yr)	Emission reduction[a]		Ref.
				tons/yr (mg/yr)	Percent	
1. Custom-made shoe cleaner reduced track-out from booths	Additional solvent	Topcoat, topcoat repair	4,230 (16,000)	15 (14)	N/A	7
2. Low-VOC cleaners	Solvent	Areas outside the topcoat, topcoat repair, and antichip/primer booths	2,000 (7,500)	7 (6)	N/A	7
3. Plastic sheeting	N/A	Sealer, surfacer	892 (3,380)	3 (3)	N/A	11
4. Fireproof paper (paper on one side, foil on the other)	Low-VOC cleaners	Parts of the area between booths	775 (2,930)	1.4 (1.3)	100[b]	4
5. Non-VOC cleaner	Low-VOC cleaners	Areas not covered by the fire-proof paper	384 (1,450)	0.69 (0.62)	100[b]	4

N/A = not available.
[a]Except where noted, all reductions were reported by the plants.
[b]The plant reported no solvent was used to clean floors.

solvent in small parts painting, fuel tank painting, touchup, wax, and repair booths.[1,13,15] One used Tyvek™ covers and wiped uncovered areas with a rag and deionized water in the basecoat booth; this plant used a waterborne basecoat.[11] One used water to clean the spray equipment in the engine primer booth.[15]

7.5.1 Advantages and Limitations of Alternatives

One plant reported advantages of robot covers are that they reduce the use of solvents, reduce cleaning time, and the waste is nonhazardous.[3] Another plant reported the use of aluminum foil on reciprocator spray arms was better than tacky coatings because the tacky coatings had a tendency to absorb moisture from the air, get thin, and drip onto the vehicles.[2] A third plant indicated wrapping and covering paint hoses with masking tape reduced cleaning time and solvent usage, but the waste still was hazardous.[4]

In addition to the limitation of tacky coatings noted above, two other limitations were reported. "Lint-free" covers were reported to have a "limited" life, and one respondent said that covers can not be put on Behr equipment.[6,8] The life span and reasons were not given.

7.5.2 Reported Solvent Usage and VOC Emission Reductions

Table 7-6 shows reported reductions for eight alternative cleaning practices at six plants.[4,6,7,11,12,15] Although the previous cleaning practice was not available for any of these examples, it is likely that it involved either wiping or spraying with solvent. Relative to the VOC emission reductions reported for alternatives implemented for other booth components, those for installing robot covers are moderate. The most benefit was achieved when covers were installed in the basecoat booths.[4,7,12]

7.6 ALTERNATIVE CLEANING PRACTICES FOR SPRAY EQUIPMENT TIPS

Only three plants implemented alternative cleaning practices for spray equipment tips that used no solvent, and these alternatives were applied for only certain tips. One reported the tips used for applying enamel paint to fuel tanks were cleaned by wiping with rags and water.[13] The second indicated the tips used to apply waterborne basecoat in the repair booth

TABLE 7-6. ALTERNATIVES FOR ROBOTS AND RELATED EQUIPMENT

Alternative	Previous cleaning practice	Booths in which alternative is used	Solvent usage reduction, gal/yr[a] (l/yr)	Emission reduction[a]		Ref.
				tons/yr (Mg/r)	Percent	
1. Cover reciprocators with aluminum foil	None	Antichip Topcoat (2)	8,295[b] (31,400)	28.6 (25.9)	N/A	4
2. Covers and plastic sheeting	N/A	Topcoat Topcoat repair	7,730 (29,300)	28 (25)	N/A	7
3. Covers	N/A	Topcoat (3) Surfacer (2) Blackwax	6,812 (25,780)	24.7[c] (22.4)	88[d]	12
4. Grease on door opener panels	N/A	Topcoat (2) Surfacer	1,872 (7,085)	6.8[c] (6.2)	60[d]	12
5. Covers	N/A	Clearcoat Surfacer	1,200 (4,500)	4.3 (3.9)	N/A	11
6. Covers	N/A	Front fascia	460 (1,740)	1.2 (1.1)	N/A	6
7. High-pressure steam/water	N/A	Wax (2)	250 (950)	0.8 (0.7)	N/A	15
8. Masking tape to hold together hoses leading to HVES spray equipment	None	Topcoat (2)	76[b] (290)	0.26 (0.24)	N/A	4

N/A = not available.
None = The alternative cleaning practice has been used since plant start-up.

[a]Except where noted, all reductions were reported by the plants.
[b]Reported reduction was an estimate of the amount of solvent that would be needed if the alternative were not used.
[c]The plant did not report emission reductions. This value was calculated based on the assumption that the xylene usage was reduced and no spent solvent was collected.
[d]The percentage reduction was not reported by the plant. It was calculated by equating it to the reported usage reduction, assuming no spent solvent was collected.

were cleaned by wiping with rags and deionized water.[11] The third replaces tips used in the guns to apply antichip coating to fuel tanks and primer to engines; no cleaning is performed in either booth.[15] Table 7-7 shows these practices eliminated solvent for cleaning these tips, but the amount of solvent that otherwise would have been needed was not reported.

Solvent was used in several ways. Many plants wiped the tips with rags and solvent (the procedures for transferring solvent to the rags were not reported).[1-4,6,8,10-13,15] Other plants dipped the tips in solvent containers, and some used a brush to scrub them.[1,7,10,14] One plant used an ultrasonic parts cleaner.[5] One plant sprayed solvent on the tips.[9]

7.7 ALTERNATIVE CLEANING PRACTICES FOR WINDOWS

Twelve plants used alternative cleaning practices for windows; four used alternatives exclusively, and eight used solvent in conjunction with alternatives. Typically, cleaning practices for windows in auxiliary booths focused on alternatives, and cleaning practices in main painting booths (primer, topcoat, and repair) consisted of either solvent in conjunction with alternatives or solvent alone. However, four plants used alternatives for cleaning windows in some main booths. Two plants relied solely on solvents for cleaning all windows. Three plants have glass walls in some or all booths; cleaning these surfaces was addressed in Section 7.2.

As shown in Table 7-1, the most common alternatives were water-based cleaners, low-VOC cleaners, scraping, and tacky coatings removed by high-pressure water blasting. Some plants also used water, hot water blasting, high-pressure steam, and plastic cling films in certain applications.

Windows in the main booths were cleaned by a variety of practices. Two plants used alternatives with no solvent; one scrubbed with a low-VOC cleaner that was applied with the scrub brush, and the other used high-pressure water blasting followed by wiping with a non-VOC cleaner.[6,7] Seven plants combined alternatives with a solvent option: (1) two wiped all windows in the main booths with a rag and solvent followed by wiping with a

TABLE 7-7. REPORTED REDUCTIONS OF ALTERNATIVES FOR SPRAY EQUIPMENT TIPS

Alternative	Previous cleaning practice	Booths in which alternative is used	Solvent usage reduction, gal/yr[a]	Emission reduction[a]		Ref.
				tons/yr	Percent	
1. Deionized water	N/A	Basecoat repair	N/A	N/A	100[a]	11
2. Water	N/A	Fuel tank	N/A	N/A	100[a]	13

N/A = not available.

[a]The plants reported no solvent was used to clean the spray equipment tips in these applications.

non-VOC glass cleaner, (2) one wiped most windows with a rag and solvent, but windows in the basecoat booth were wiped with rags soaked in water (this plant used a waterborne basecoat paint), (3) one masked most windows with a tacky coating that was washed off with water, but windows in the Bell zones were unmasked and wiped with solvent, (4) one sprayed or wiped solvent on the windows, scrubbed, and then washed with water, (5) one brushed solvent on most windows, but those in the basecoat door jam cut-in areas were covered with plastic cling film so that no solvent was needed for cleaning, and (6) one used high-pressure water blasting followed by spraying solvent on stubborn spots.[1,3,4,8,10,11,15] Three plants cleaned all windows by wiping with a rag and solvent.[12-14]

Cleaning practices for auxiliary booths were reported by 11 plants, 10 of which used alternatives without solvent in a variety of booths (5 blackout, 4 final repair/touchup, 3 wax, 2 bumper, small parts, wheel, sealer, and antichip for fuel tank booths). Five of these plants eliminated VOC emissions from some of these booths, primarily by scraping or by wiping the windows with a non-VOC cleaner.[1,2,6,14,15] Other alternatives that eliminated VOC emissions included (1) high-pressure steam in the wheel painting booth and one of the final touchup booths, (2) wiping with dry rags followed by wiping with a non-VOC cleaner in the sealer booth, and (3) hot water blasting in one of the wax booths.[8,11,15] Three plants reduced VOC emissions by using low-VOC cleaners in two blackout booths and a touchup booth.[3,4,7] One plant wiped windows in an underbody booth with rags and solvent after scraping them.[1] One plant wiped the windows in all auxiliary booths with rags and solvent.[12]

7.7.1 <u>Advantages and Limitations of Alternatives</u>

One plant used plastic cling film on the windows in the basecoat door jam cut-in areas because it is easy to use and dispose of (although it is treated as hazardous waste), and it eliminates the use of cleaning solvents for those windows.[4] One plant indicated the advantages of a non-VOC glass cleaner, besides containing no VOC, was its low cost. However, it has limited cutting power and can only be used to clean light overspray.[15] Hot water blasting and tacky coatings followed by water blasting offer the same advantages described earlier for wall cleaning.

7.7.2 Reported Solvent Usage and VOC Emission Reductions

As shown in Table 7-8, one plant reported reductions for an alternative cleaning practice for windows. By covering some of the windows in the basecoat booths, the plant estimated solvent usage was reduced by about 6,000 gal/yr (23,000 l/yr). The previous solvent application procedure was not provided.[4]

7.8 ALTERNATIVE CLEANING PRACTICES FOR FIXTURES

Twelve plants identified alternative cleaning practices used to clean fixtures. Six identified the items they classified as fixtures, three identified some items, and three used only the generic term "fixtures." Only three of the 12 plants reported using solvent. Three plants reported no fixtures in their booths.

Table 7-1 lists the reported alternative cleaning practices for fixtures. Specifically, one plant indicated car body carriers were taken to a separate area at the plant to be water blasted.[10] Three plants reported different practices for cleaning center track drive covers: (1) "flooding" with a low-VOC cleaner, followed by scraping and flushing with water, (2) using grease and removing it by scraping, and (3) using a tacky coating and removing it by scraping with a flat-bladed Berylco™ (beryllium and copper alloy) scraper once a week and water blasting once a year.[2-4] One plant reported scraping the exhaust fan and stack, and another greased the stack to improve the effectiveness of water blasting.[5,13] One plant used masking tape, grease, aluminum foil, and water blasting on parts of the conveyors.[12] One plant used water, hot water, and high-pressure water to clean certain lights.[15] One plant sent jigs offsite to be burned.[11] The cleaning practices for unspecified fixtures included scrubbing with a low-VOC cleaner; using Tyvek™, plastic, aluminum foil, or unspecified covers; masking with grease; and using high-pressure steam.[1,5,8,11,12,14]

TABLE 7-8. REPORTED REDUCTIONS OF ALTERNATIVES FOR WINDOWS

Alternative	Previous cleaning practice	Booths in which alternative is used	Solvent usage reduction, gal/yr[a] (l/yr)	Emission reduction[a]		Ref.
				tons/yr (Mg/yr)	Percent	
1. Cover with plastic cling film	Solvent[b]	Topcoat (2)	6,040 (22,900)	20 (18)	100[c]	4

[a]All reductions were reported by the plant.
[b]The plant did not report the application procedure.
[c]The plant reported that no solvent is needed to clean the windows covered with the plastic film.

Three plants wiped various fixtures with rags and solvents. One plant wiped car body carriers and conveyor return covers.[10] Another wiped x-tree stands and drip pans.[13] The third wiped light fixtures in certain booths.[15]

7.8.1 Advantages and Limitations of Alternatives

The Berylco™ scraper prevents sparks as required by the plant's Fire/Safety Department, but it can only be used for scraping hardened paint (on tacky coatings) from the center track drive covers and floor grate support structures.[4] This plant also indicated annual water blasting is very time consuming (about 5 days).[4] One plant used grease and various covers on the conveyor because it reduced the amount of time needed to clean.[12] Using grease and water blasting to clean the stack was found to be the quickest and most cost-effective method.[5] Advantages and limitations of other alternatives were not reported.

7.8.2 Reported Solvent Usage and VOC Emission Reductions

Table 7-9 presents the reported reductions for seven alternative cleaning practices at four plants. One of the highest reported reductions of alternative cleaning practices for any booth component resulted from changing the way center track drive covers were cleaned at one plant.[2] Another plant estimated the alternative cleaning practice for center track drive covers (and floor grate support structures) avoided the use of nearly as large a quantity of solvent; the percentage attributable to center track drive covers is unknown.[4] Alternative cleaning practices based on the use of various covers for conveyors and miscellaneous items reportedly resulted in very small reductions.[11,12]

7.9 ALTERNATIVE CLEANING PRACTICES THAT AFFECT MULTIPLE BOOTH COMPONENTS

Ten plants reported a variety of work practice changes that reduced solvent usage and associated VOC emissions from cleaning more than one type of booth component. The changes were not in the cleaning activities but rather in work practices. They were reported to reduce waste, conserve solvent, or increase the efficiency of the solvent used.

TABLE 7-9. REPORTED REDUCTIONS OF ALTERNATIVES FOR FIXTURES[1-15]

Alternative	Previous cleaning practice	Booths in which alternative is used	Solvent usage reduction, gal/yr[a] (l/yr)	Emission reduction[a]		Ref.
				tons/yr (Mg/yr)	Percent	
1. "Flood" center track drive cover with a lower VOC solvent; scrape residue off after 15 to 20 minutes	Spray center track drive cover with solvent	Color (2) Reprocessing	37,353 (141,380)	127 (115)	N/A	2
2. Use tacky coating on center track drive covers, I-beams, and support rails; scrape off with Berylco™ scrapers[b]	None	Antichip Topcoat (2) Repair (2)	27,900 (105,600)	84 (76)	100	4
3. Cover fixtures with plastic sheeting	None	Topcoat (4) Surfacer (2) Tutone Repair (2) Bumper (2) Blackwax	572 (2,170)	2.1[c] (1.9)	50[d]	12
4. Cover conveyor with plastic	N/A	Sealer	312 (1,180)	1.05 (0.95)	N/A	11
5. Cover parts of conveyors with masking tape	N/A	Topcoat (2) Tutone Repair Surfacer	78 (300)	0.28[c] (0.25)	50[d]	12
6. Cover parts of fixtures, cubby holes, and conveyors with aluminum foil	N/A	Topcoat (4) Surfacer (2) Tutone Repair (2) Blackwax Bumper (2)	39 (150)	0.14[c] (0.13)	74[d]	12

TABLE 7-9. (continued)

Alternative	Previous cleaning practice	Booths in which alternative is used	Solvent usage reduction, gal/yr[a] (l/yr)	Emission reduction[a]		Ref.
				tons/yr (Mg/yr)	Percent	
7. Cover with plastic miscellaneous items for which specific covers are not made	N/A	Topcoat (4) Surfacer Blackwax Deadener (2) Repair Bumper Sealer (2)	26 (98)	0.09[c] (0.08)	67[d]	12

N/A = not available.
None = The alternative cleaning practice has been used since plant startup.

[a]Except where noted, all reductions were reported by the plants.
[b]The I-beams and support rails are part of the floor grate support structure. Thus, only part of the estimated reductions is for fixtures.
[c]The plant did not report emissions reductions. This value was calculated based on the assumption that xylene usage was reduced and no spent solvent was collected.
[d]The percentage reduction was not reported by the plant. It was calculated by equating it to the reported usage reduction, assuming no spent solvent was collected.

Changes to the solvent application method were reported by six of the plants surveyed. Cleaning solvent usage is reduced, primarily, through reducing the amount of solvent applied to the object being cleaned. To eliminate applying an excess amount of solvent, the direct application of cleaning solvents is reduced as much as possible or more efficient applicators are used. For example, cleaning solvents are applied onto rags instead of the object being cleaned; the object being cleaned is then wiped with the wetted rags. Alternatively, more efficient applicators such as sprayers are used, rather than just "sloshing" the solvent onto the object to be cleaned.[3,4,6,7,9,12]

One plant reported reducing the frequency of cleaning. The cleaning frequency was changed from once a week to once every 2 weeks. This resulted in an overall decrease in labor requirements and an overall reduction in cleaning solvent usage. Although paint buildup between cleanings doubled, solvent usage during each cleaning shift increased by only 10 percent.[8]

Training the labor force on minimizing the use of cleaning solvents was reported as a management practice implemented by three plants.[5,12,14] The purpose of the training was to increase personnel awareness of exercising prudence in regard to the use of cleaning solvents. The training was provided through either seminars or documents that present detailed, simple, step-by-step instructions including pictures of every cleaning step.[12,14] Also, implementing programs (e.g., a total toxic organic program to segregate toxic or hazardous materials from nontoxic and nonhazardous materials) and establishing guidelines to increase personnel awareness with respect to handling hazardous materials was reported to have reduced cleaning solvent usage at one facility.[5]

Tracking the use and maintaining an inventory of cleaning solvents was reported as a management practice used by eight plants. The tracking was facilitated through installing measuring devices in the solvent reservoirs and/or computerized or conventional tracking procedures as well as maintaining an inventory of the cleaning solvent usage.[3,5-8,10,11,14] In one plant, the usage was monitored for each booth.[14]

Restricting access to cleaning solvents was reported as a management practice used by one plant.[6] The access to solvents can be limited indirectly through providing the labor force with limited quantities of cleaning solvents in cans or small buckets instead of allowing unrestricted access to solvent tanks or totes.

Recycling or reclamation and reuse of solvents was reported as a solvent management practice used by one plant. All spent solvents, even very small quantities, are collected. Reuse of one cleaning solvent resulted in a 50-percent reduction of the original quantity used.[11]

7.10 REFERENCES FOR SECTION 7

1. Response to Section 114 Information Request for AutoAlliance International, Inc., Flat Rock, MI. August 21, 1992.

2. Response to Section 114 Information Request for Chrysler Corporation, Belvidere, IL. August 1, 1992.

3. Response to Section 114 Information Request for Chrysler Corporation, Dodge City, MI. August 14, 1992.

4. Response to Section 114 Information Request for Chrysler Corporation, Sterling Heights, MI. August 14, 1992.

5. Response to Section 114 Information Request for Ford Motor Company, Chicago, IL. August 14, 1992.

6. Response to Section 114 Information Request for Ford Motor Company, Dearborn, MI. August 17, 1992.

7. Response to Section 114 Information Request for Ford Motor Company, Twin Cities, MN. August 17, 1992.

8. Response to Section 114 Information Request for General Motors Corporation, Fort Wayne, IN. August 14, 1992.

9. Response to Section 114 Information Request for General Motors Corporation, Moraine, OH. August 14, 1992.

10. Response to Section 114 Information Request for General Motors Corporation, Oklahoma City, OK. August 14, 1993.

11. Response to Section 114 Information Request for Honda of America Manufacturing, Inc., East Liberty, OH. August 12, 1992.

12. Response to Section 114 Information Request for Honda of America Manufacturing, Inc., Marysville, OH. October 29, 1992.

13. Response to Section 114 Information Request for Nissan Motor Manufacturing Corporation, USA, Smyrna, TN. September 28, 1992.

14. Response to Section 114 Information Request for Subaru-Isuzu Auto Incorporated, Lafayette, IN. September 15, 1992.

15. Response to Section 114 Information Request for Toyota Motor Manufacturing, USA, Inc., Georgetown, KY.

16. Memorandum and attachments from Azar, S., MRI, to Serageldin, M., EPA/CPB. September 28, 1992. Site Visit--Chrysler Corporation Jefferson North Assembly Plant, Detroit, MI.

APPENDIX A

FACILITY INFORMATION

TABLE A-1. SUMMARY INFORMATION ON AUTO ASSEMBLY PLANTS AS OF 1991

Manufacturing company (year operation started)	Location (State/city/county)	Production hours [a] Shifts worked/d; total hr/yr	Production lines	Production rate, vehicle/yr (production year)	No. of employees			
					Plant	All types of cleaning	Paint shop operations	Paint shop cleaning
AutoAlliance International, Inc. (1987)	Michigan/ Flat Rock/ Wayne	2; 3,771	Probe MX6 626	Total = 167,900	3,800	90	432	68
Chrysler Corp.-- Belvidere (1965)	Illinois/ Belvidere/ Boone	2; 2,877	Dynasty New Yorker Fifth Avenue Imperial	178,087 (91)	3,041	93	343	15
Chrysler Corp.-- Dodge City (1938)	Michigan/ Warren/ Wayne	2; 3,614	N+D Truck	177,134 (91)	2,851[b]	121[b]	612[b]	32b[b]
Chrysler Corp.-- Sterling Heights (1984)	Michigan/ S.H./ Macomb	2; 2,729	Shadow Sundance	137,842 (91)	2,955	61	331	29
Ford Motor Company-- Chicago (1924)	Illinois/ Chicago/ Cook	2; 3,360	Taurus Sable	218,328	3,100	54	14	12
Ford Motor Company-- Dearborn (1918)	Michigan/ Dearborn/ Wayne	2; 1,915	Mustang	81,563	2,342	28	240	26
Ford Motor Company-- Twin Cities (1925)	Minnesota/ Saint Paul/ Ramsey	2; 2,888	Light-duty truck: F-Series Ranger	125,275	1,955	57	285	28
General Motors Corp.-- Fort Wayne (1986)	Indiana/ Roanoke/ Allen	2; 3,322	C/K Full-size pickup truck	170,501	2,676	194	238	35
General Motors Corp.-- Moraine (1981)	Ohio/ Moraine/ Montgomery	2; 3,786	Pickup truck 4-Door utility vehicle	Total = 178,520	Approx. 3,000	Approx. 100	Approx. 300	32

TABLE A-1. (continued)

Manufacturing company (year operation started)	Location (State/city/county)	Production hours [a] Shifts worked/d; total hr/yr	Production lines	Production rate, vehicle/yr (production year)	No. of employees			
					Plant	All types of cleaning	Paint shop operations	Paint shop cleaning
General Motors Corp.–Oklahoma City (1979)	Oklahoma/ Oklahoma City/ Oklahoma	2; 3,552	Mid-size "A" car line: Oldsmobile Cutlass Ciera Buick Century	228,925	5,215	208	716	25
Honda of America Mfg., Inc. (1983, 1987)[c]	Ohio/ Marysville/ Union	2; 4,000	Accord: 2-door 4-door Wagon	356,967 356,967 356,967	5,812 (H) 225 (T)	d	932 (H) 54 (T)	3 (H) Contract cleaning crew (96)
Honda of America Mfg., Inc.– East Liberty (1989)	Ohio/ East Liberty/ Logan	2; 4,000	Civic Accord	84,968 9,252	1,850	e	384	120 (H) Contract cleaning crew (23 to 37)
Nissan Motor Manufacturing Corporation, USA (1983)	Tennessee/ Smyrna/ Rutherford	2; 3,840	Sentra Pickup truck	262,000	Approx. 3,500	172	334	70
Subaru-Isuzu Automotive (1989)	Indiana/ Lafayette/ Tippecanoe	2; 1,864	Legacy Rodeo Pickup truck	57,945 (91) 32,454 (91) 25,898 (91)	1,914	Contracts all cleaning	247	Contracts all cleaning
Toyota Motor Manufacturing, USA, Inc. (1988)	Kentucky/ Georgetown/ Scott	2; 4,080	Camry	187,951	4,000	3,000	450	100

[a]Production hours may not reflect hours spent cleaning.
[b]The figures are representative and may vary.
[c]Operations for Line 2 started in 1983, and for Line 1 started in 1987. Full-time Honda employees designated by (H); temporary employees designated by (T).
[d]All production employees may have cleaning responsibilities as needed for their job process.
[e]All production associates may have some responsibility for cleaning; plus, all associates in the paint production process have responsibility to cleaning their work area, which may include paint equipment.

TABLE A-2. INFORMATION ON PAINT SPRAY BOOTHS, USE OF CLEANING SOLVENTS, AND VOC EMISSIONS

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
AutoAlliance International	(1A) Underfloor spray, PVC under-body coating of the vehicle exterior	Body		131'L x 14'W x 20'H	Downdraft, removable grates, low-pressure venturi			
	(2A) Stoneguard spray, rocker panel coating (exterior)	Body		117'L x 16'W x 20'H	Downdraft, removable grates, low-pressure venturi	Grow Non-Meth Hasco Wolverine		
	(3A) Primer, surface primer application	Entire body		253'L x 20'W x 20'H	Downdraft, removable grates, low-pressure venturi	Grow Non-Meth Hasco Wolverine		
	(4A) Enamel 1, enamel topcoat (basecoat & clearcoat) application	Entire body		288'L x 20'W x 20'H	Downdraft, removable grates, wet cyclone	Grow Non-Meth Hasco Wolverine		
	(5A) Enamel 2, enamel topcoat (basecoat & clear-coat) application	Entire body		288'L x 20'W x 20'H	Downdraft, removable grates, wet cyclone	Gro Non-Meth Hasco Wolverine		
	(6A) Two-tone, two-tone application of topcoat	Entire body		118'L x 18'W x 20'H	Downdraft, removable grates, wet cyclone	Grow Non-Meth Hasco Wolverine		
	(7A) Interior parts	Parts		112'L x 16'W x 20'H	Downdraft, removable grates, paint arrestor	Grow Non-Meth Hasco Wolverine		
	(1B) Surface primer, primer surfacer application to plastic bumper	Bumper, Fascia		36'L x 18'W x 12'H	Downdraft, removable grates, low-pressure venturi			
	(2B) Front bumper topcoat, topcoat application to plastic bumper	Bumper, Fascia		48'L x 18'W x 12'H	Downdraft, removable grates, low-pressure venturi			

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
Autoalliance International (cont'd)	(3B) Front bumper clearcoat, clearcoat application to plastic bumper	Bumper, Fascia		48'L x 18'W x 12'H	Downdraft, removable grates, low-pressure venturi			
	(4B) Rear bumper topcoat, topcoat application to plastic bumper	Rear bumper		39'L x 18'W x 12'H	Downdraft, removable grates, low-pressure venturi			
	(5B) Rear bumper clearcoat, clearcoat application to plastic bumper	Rear bumper		39'L x 18'W x 12'H	Downdraft, removable grates, low-pressure venturi			
	(6B) Small parts topcoat, topcoat application	Exterior garnish & mirror cover		48'L x 12'W x 12'H	Sidedraft, removable grates, waterwash walls			
	(7B) Small parts clearcoat, clear coat application	Exterior garnish & mirror cover		48'L x 12'W x 12'H	Sidedraft, removable grates, waterwash walls			
	(8B) Interior parts spray, lacquer finish application	Glove box cover & consoles		48'L x 12'W x 12'H	Sidedraft, removable grates, waterwash walls			
	(9B) Rear bumper primer, black-accent stripes application	Bumper		20'L x 18'W x 12'H	Downdraft, removable grates, low-pressure venturi			
Annual use of solvents for booth Nos. 2A + 3A + 4A + 5A + 6A + 7A						Grow Non-Meth Hasco Wolverine	13,300 1,200	41.4 3.4
Annual use of solvent for booth 1A						Hasco Wolverine	100	0
Annual use of solvents for all booths						All Solvents	14,600	45

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
Chrysler (Belvidere)	(1) North color, topcoat application (both base & clear coats)	Entire body	60,000	240'L x 20'W x 12'H	Downdraft, removable grates, floor scrubbers	Sol-365 Polystrip 3290 Sol-432	18,076 1,565 1,710	61.5 4.6 6.1
	(2) South color, topcoat application (both base & clear coats)	Entire body	60,000	240'L x 20'W x 12'H	Downdraft, removable grates, floor scrubbers	Sol-365 Polystrip 3290 Sol-432	18,076 1,565 1,710	61.5 4.6 6 1
	(3) Reprocess, topcoat application (both base & clear coats)	Entire body	4,840	120'L x 20'W x 12'H	Downdraft, removable grates, floor scrubbers	Sol-365 Polystrip 3290 Sol-432	4017 348 380	13.7 1 0 1.3
	(4) Underbody Black-out, black-out of underbody components	Under body components	2,000	60'L x 24'W x 20'H	Sidedraft, concrete floor	Naphtha	negligible	
Annual use of solvents for all booths						All solvents	47,447	160
Chrysler (Dodge City)	(1) Color 1, topcoat application	Entire body	136,617	380'L x 20'W x 13'H*1	Zoned downdraft, removable grates, waterwash trough			
	(2) Color 2, stoneguard*2 & topcoat application	Panel, entire body	195,167*2	380'L x 20'W x 13'H*1	Zoned downdraft, removable grates, waterwash trough			
	(3) Two-tone, stoneguard*2 & topcoat application	Panel, entire bodies	58,550*2	380'L x 20'W x 13'H*1	Zoned downdraft, removable grates, waterwash trough,			
	(4) Repair*1, high bake & topcoat repair	Panel, spots	N/Av.(varies)	280'L x 20'W x 13'H	Zoned downdraft, removable grates, waterwash trough			
	(5) Chassis black, chassis black application	Chassis	4,337	41'L x 20'6"W x 12'H	Downdraft, raised platform, waterfall wash			
	(6) Black-out, black-out application	Grill, wheel wells	7,787	30'L x 20'W x 11'H	Downdraft, removable grates, dry booth			

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
Chrysler (Dodge City) (cont'd)	(7) Low-bake repair, low-bake topcoat repair	Spots only	N/Av.(varies)	74'L x 18'W x 12'H*1	Downdraft, removable grates, waterwash trough			
Annual use of solvents for booth Nos. 1+2+3+4+7						AX-400 Purge Thinner (MS-8464) Rambo	55,385 10,034 1,100	188 36 3.5
Annual use of solvents for booth No. 6						Glass Cleaner Windex™	5 1	0 0
Annual use of solvents for all booths						All Solvents	66,525	228
Chrysler (Sterling Heights)	(1) Two-tone, antichip & two-tone application	Rocker panels	6,841	217'L x 18'W x 19'H	Downdraft, removable grates, floodsheets			
	(2) Color I, color I application	Entire body	82,385	190'L x 18'W x 19'H	Downdraft, removable grates, floodsheets			
	(3) Color II, color II application	Entire body	82,385	190'L x 18'W x 19'H	Downdraft, removable grates, floodsheets			
	(4) High-bake repair, high bake repair application	Body spot repair	3,295	99'L x 18'W x 19'H	Downdraft, removable grates, floodsheets			
	(5) Black-out, black-out application	Wheel wells	3,809	184'L x 16.5'W x 17.5'H	Downdraft, removable grates, dry filter			
	(6) Low-bake repair, low bake repair application	Body spot repair	1,640	two booths, each booth: 25'L x 18'W x 19.5'H	Downdraft, removable grates, floodsheets			
Annual use of solvents for booths Nos. 1+2+3+4						MS-8464 (Purge Solvent) AX-400 Shapkleen 2 White Vincote	4,095 18,949 1,920 385	14.3 65.4 3.5 1.6

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
Annual use of solvents for booth No. 5						Nasco Glass Cleaner	75	0
Annual use of solvents for booth No. 6						MS-8464 AX-400	41 191	0.1 0.7
Annual use of solvents for all booths						All solvents	25,656	86
Ford (Chicago)	(1) Topcoat application	Car body	34,000	280'L x 20'W x 20'H	Downdraft, removable grates, center venturi			
	(2) Topcoat application	Car body & panel repair	38,000	280'L x 20'W x 20'H	Downdraft, removable grates, center venturi			
	(3) Topcoat application & two-tone repair	Not in use	0	210'L x 20'W x 20'H	Downdraft, removable grates, single sidedraft			
	(4) Primer/guide coat application	Car body	67,000	210'L x 20'W x 20'H	Downdraft, removable grates, 2/3 center venturi & 1/3 back sections			
	(5) Flange primer/black-out application	W/shield, B/lite, Qtr glass window flange	1,200	60'L x 18'W x 12'H	Dry filter downdraft, removable grates, center filters			
	(6) Topcoat application & repair on wheels	Vertical panel repair	240	50'L x 16'W x 12'H	Wet pan downdraft, removable grates, sidedraft			
	(7) Transit coating application	Hood, roof, D/LID	25,000	30'L x 18'W x 10'H	Dry filter side exhaust, concrete floor with tarpaper, no supply air (warm weather only)			
Annual solvent usage for all booths						Gage 31295 (AAD 803)™ Product Sol 50-8-3™ (hose cleaner) Product Sol 777™ (floor & wall cleaner) Peerless 813™ (floor carpet mask)	85,000 10,560 2,292 1,650	304 38.5 3.8 0.3
						All solvents	99,502	347

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
Ford (Dearborn)	(12) Primer and antichip application	Body	193,600	130'L x 23'W x 18'H	Modular downdraft, removable grates, waterwash walls			
	(14) Topcoat application	Body	193,600	240'L x 23'W x 18'H	Modular downdraft, removable grates, waterwash walls			
	(16) Topcoat repair & high bake	Spoiler, hood, fender, etc.	19,360	120'L x 18'3''W x 14'3''H	Modular downdraft, removable grates, waterwash walls			
	(21) Final repair & low bake	Miscellaneous areas of vehicle	1,980	45'L x 17'8''W x 15'H	Modular downdraft, removable grates, waterwash walls			
	(40) Front fascia	Front bumper	16,640	110'L x 17'8''W x 13'5''H	Modular downdraft, removable grates, waterwash walls			
Annual use of solvents for all booths						Xylene	5,278	14
Ford (Twin Cities)	(1) Main enamel, topcoat application	Cab, box	112,500	300'L x 20'W x 12'H	Downdraft, removable grates, scrubber			
	(2) Two-tone, topcoat application, accent, repair	Cab, box	28,000	140'L x 20'W x 12'H	Downdraft, removable grates, scrubber			
	(3) Antichip, antichip & primer application	Cab, box	4,000	85'L x 20'W x 12'H	Downdraft, removable grates, scrubber			
	(4) Mini booth, polish & minor touch up	Cab, box	0 to 10	45'L x 20'W x 12'7''H	Downdraft, removable grates, dry filter			
	(8) Final repair, topcoat repair	Cab, box	200	32'L x 16'W x 12'H	Downdraft, removable grates, waterwash walls			
	(9) Transit coat, wax coat spray	Cab, box	50,000	25'L x 16'W x 14'H	Sidedraft, removable grates, dry filter			

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
Ford (Twin Cities) (cont'd)	(10) Frame touch-up, touch-up	Frames (inactive since 1989)	0	32'L x 18'W x 14'H	Downdraft, removable grates, dry filter			
Annual solvent usage for all booths						CN-31295™ (purge solvent)	15,180*3	27.9
						Ethylene glycol monobutyl ether	935	
						Cellosolve acetate	50	
						n-Butyl acetate	53	
						Hi Sol 10™	1,914	
						Toluene	9,896	
						Xylene	51,798	
						Hi Sol 15™	669	
						Butyl cellosolve acetate	13	
						Methyl amyl ketone	16	
						Methyl ethyl ketone	298	
						DTR-600™ (lacquer thinner)	43	
						E-227™	4,015	
						Tennant-658™ cleaner	950	
						Product Sol-793™ (floor cleaner)	770	
						Product Sol 39-11-11™	213	
						AWR-5441™	660	
						Zeprid-E™ (oven cleaner)	1,100	
						1394-Zeeper™	11	
						S-90™ Oven Cleaner	110	
						CN-71712™ (floor cleaner)	220	
						DCT sealer cleaner	165	
						CN-71585™ (line stripper)	3,960	
						RK-5352™ (flushing resin)	5,000	
						Windex™	100	
						All solvents	98,139	78*4

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
GM (Fort Wayne)	(1) to (10) Basecoat application	Cab, box, front-end sheet metal	187,484	35'L x 20'W x 12'H	Modular downdraft, fold-up grates, waterwash walls	Atlantis Golden Star Isopropanol Wonderstrip Grow 6518		
	(1) to (10) Clearcoat application	Cab, box, front-end sheet metal	165,438	35'L x 20'W x 12'H	Modular downdraft, fold-up grates, waterwash walls	Atlantis Golden Star Isopropanol Wonderstrip Grow 6518		
	Antichip spray, antichip application	Cab, box	13,361	80'L x 20'W x 12'H	Modular downdraft, fold-up grates, waterwash walls	Grow 6518		
	Wheel spray, wheel paint application	Wheel	1,942	30.5'L x 11'W x 9.8'H	Waterwall sidedraft, removable grates, recyclable emulsion	Grow 6518		
	Final repair spray, base coat/clearcoat application	Cab, box front end sheet metal	Variable	30.5'L x 20'W x 12'H	Modular downdraft, removable grates,	Grow 6518		
Annual solvent usage for all booths						Atlantis Golden Star Isopropanol Wonderstrip Grow 6518	43,230 16 200 6,000 3,640	154 0 0.7 25.5 12.6
						All solvents	53,086	193
GM (Moraine)	(202) Antichip application	Cab, box, utility	46,397 to 81,216	125'L x 18'W x 12'H	Downdraft, grates, glass walls			
	(204) Topcoat application (two-tone)	Cab, box, utility	41,558 to 73,310	135'L x 18'W x 12'H	Downdraft, grates, glass walls			
	(206) Topcoat application (main line)	Cab, box, utility	77,112 to 107,698	260'L x 18'W x 12'H	Downdraft, grates, glass walls			

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
GM (Moraine) (cont'd)	(208) Topcoat application (repair)	Cab, box, utility	7,711 to 10,770[*5]	135'L x 18'W x 12'H	Downdraft, grates, glass walls			
	(210) deadener application	Cab, box, utility	Approximately 43,200	75'L x 18'W x 12'H	Downdraft, concrete floor, glass walls			
	(302) Antichip application	Sheet metal	14,256 to 15,120	80'L x 18'W x 12'H	Downdraft, grates, glass walls			
	(304) Topcoat application (two-tone)	Sheet metal	14,256 to 15,120	100'L x 18'W x 12'H	Downdraft, grates, glass walls			
	(306) Topcoat application (main line)	Sheet metal	14,256 to 15,120	120'L x 18'W x 12'H	Downdraft, grates, glass walls			
	(FR-E) Final repair	All	14,975 to 20,686[*6]	30'L x 18'W x 12'H	Downdraft, grates, glass walls			
	(FR-W) Final repair	All	14,975 to 20,686[*6]	30'L x 18'W x 12'H	Downdraft, grates, glass walls			
	(CB-1) Chassis black	Fuel tank	8,640	40'L x 18'W x 12'H	Bottom exhaust, grates, glass walls			
	(CB-2) Chassis black	Fuel tank	2,160	21'L x 13'W x 12'H	Downdraft dry filter, concrete floor and grates			
Annual use of solvents for all booths (No solvent used in booths 210, CB-1, and CB-2)						TEXO LP 868	Unknown	
						TEXO LP 1582	31,704	112[*7]
						TEXO LP 856	Unknown	
						Isopropanol	Unknown	
						Xylene	7,205	26[*7]
						Reconstituted purge	150,608	519[*7]
						All solvents	189,517	657[*7]

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
GM (Okla. City)	(1) Prime:			270'L x 20'W x 12'H	Downdraft, removable grates, Myrmade scrubber			
	Antichip application	Rocker panel	7,700					
	Primer surfacer application	Vehicle exterior	127,100					
	Basecoat application	Cowl & trunk interior	38,700					
	Semigloss black application	Header @ window & center post	10,500					
	(2) First color:			375'L X 20'W x 12'H	Downdraft, removable grates, Myrmade scrubber			
	Basecoat application	Vehicle exterior & motor compartment	834,300					
	Clearcoat application	entire exterior	834,300					
	(3) Second color, basecoat/clearcoat application	On repaired areas only	66,700	280'L x 20'W x 12'H	Downdraft, removable grates, Myrmade scrubber			
	(4) Third color, no painting is performed	None	Not applicable	210'L x 20'W x 12'H	Downdraft, removable grates, Myrmade scrubber			
	(5) Small parts, fascia painting	Bumpers	7,700	195'L x 20'W x 12'H	Downdraft, removable grates, waterwash walls			
	(6) Steering column, steering column painting	Steering column	550	30'L x 10'W x 12'H	Downdraft, removable grates, waterwash walls			

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
GM (Okla. City) (cont'd)	(7) Final process, spot repair painting	repaired areas	Unknown	65'L x 30'W x 12'H	Downdraft, removable grates, waterwash walls			
Annual use of solvents for all booths						Grow 6518 and 5601 Polystrip 3450 LP1582*8 and Texo1664 Zepride*8 IMS Thinstrip*9	45,796 4,500 42,000 2,600 2,800	138 13.5 88 2.8 8.4
						All solvents	97,696	251
Honda (East Liberty)	K002 Sealer			363'L x 23'W x 14'H	Downdraft, removable grates			
	K002 Deadener			147'L x 23'W x 16'3"H	Downdraft, removable grates			
	K003 Surfacer			242'L x 23'W x 15'9"H	Downdraft, removable grates, baffle plates			
	K005 Base Coat No.1			200'L x 23'W x 16'H	Downdraft, removable grates, baffle plates			
	K005 Clear Coat No.2			152'7"L x 23'W x 16'H	Downdraft, removable grates, baffle plates			
	K006 Base Coat No.2			200'L x 23'W x 16'H	Downdraft, removable grates, baffle plates			
	K006 Clear Coat No.2			152'7"L x 23'W x 16'H	Downdraft, removable grates, baffle plates			
	K007 Base coat repair			70'L x 23'W x 14'6"H	Downdraft, removable grates, baffle plates			
	K007 Clear coat repair			42'7"L x 23'W x 14'6"H	Downdraft, removable grates, baffle plates			
	K008 Spot repair			26'L x 20'W x 11'H	Downdraft, removable grates, waterpan			
	K009 Wax booth			150'L x 23'W x 18'H	Downdraft, removable grates			

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
Honda (East Liberty) (cont'd)	K010/K016 Final Wax			70'L x 15'8"W x 16'H	Downdraft, removable grates, underbooth watersheet			
	K011 Final touch-up			21'4"L x 14'10"W x 10'H	Downdraft, removable grates, underbooth watersheet			
	K012 Back side			162'L x 20'W x 11'H	Downdraft, removable grates			
Annual use of solvents for all booths						Xylene Isopropyl alcohol Butyl cellosolve Mineral spirits Citrosolve™	26,771 4,666 200 70 100	97.2 15 3 0.8 0.2 0.3
						All solvents	31,807	114
Honda (Marysville)	(1) KJ final repair, repair paint process (system paint)	Panel parts	variable	22'L x 15'W x 15'H	Downdraft, removable grates, wet pan			
	(2) KJ final repair, protective wax horizontial	Body	38,598 to 40,152	24'L x 11'W x 10'H	Downdraft, removable grates, dry booth			
	(3) Black wax, black wax application to under floor	Underside of floor	N/av. (763 to 794 lb of wax is used)	90'L x 20'W x 11'H	Downdraft, removable grates, dry booth			

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
Honda (Marysville) (cont'd)	(4) Final Touch-Up 1, repair paint process (system paint)	Panel parts	Variable	25'L x 15'W x 12'H	Downdraft, removable grates, dry booth			
	(5) Final Touch-Up 2, repair paint process (system paint)	Panel parts	Variable	25'L x 15'W x 9'H	Downdraft, removable grates, dry booth			
	(6) Final Touch-Up 3, repair paint process (lacquer)	Interior parts	Variable	25'L x 15'W x 9'H	Downdraft, removable grates, dry booth			
	(7) Final Touch-Up 4, repair paint process system paint	Panel parts	Variable	25'L x 15'W x 13'H	Downdraft, removable grates, wet pan			
	(8) Final Touch-Up 5, repair paint process system paint	Panel parts	Variable	25'L x 15'W x 13'H	Downdraft, removable grates, wet pan			
	(9) Line 1 sealer, sealer application	Body	N/Av. (4,657 lbs/shift is used)	70'L x 17'W x 12'H	Downdraft, removable grates, dry booth			
	(10) Line 1 deadener, PVC undercoating	Body	N/Av. (3,124 lbs/shift is used)	66'L x 13'W x 12'H	Downdraft, removable grates, dry booth			
	(11) Line 1 primer surfacer, primer & antichip application	Body	Primer: 38,100 Antichip: 8,250	209'L x 21'W x 18'H	Downdraft, removable grates, scrubbers			
	(12) Line 1 Topcoat A, topcoat application	Body	38,100	168'L x 21'W x 18'H	Downdraft, removable grates, scrubbers			
	(13) Line 1 Topcoat B, topcoat application	Body	38,100	168'L x 21'W x 18'H	Downdraft, removable grates, scrubbers			

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
Honda (Marysville) (cont'd)	(14) Line 1 repair, topcoat repair	Body	758	130'L x 17'W x 13'H	Downdraft, removable grates, scrubbers			
	(15) Line 1 two-tone, small repair & topcoat application	Body	75	23'L x 15'W x 13'H	Downdraft, removable grates, Dyna tubes			
	(16) Line 1 Wax 1, inner wax interior	Body	135 for booths 16 + 17	94'L x 17'W x 11'H	Downdraft, removable grates, dry booth			
	(17) Line 1 Wax 2, floor wax	Body		66'L x 17'W x 19'H	Downdraft, removable grates, dry booth			
	(18) Line 2 sealer, paint sealer application	Body	N/Av. (4,275 lbs is used)	50'L x 16'W x 11'H	Downdraft, removable grates, dry booth			
	(19) Line 2 deadener, PVC/Deadener application	Body	N/Av. (2,175 lbs is used)	68'L x 17'W x 19'H	Downdraft, removable grates, dry booth			
	(20) Line 2 primer surfacer, primer surfacer application	Body	38,100	265'L x 17'W x 15'H	Downdraft, removable grates, dyna tubes			
	(21) Line 2 Topcoat A, basecoat application	Body	38,100	225'L x 17'W x 15'H	Downdraft, removable grates, dyna tubes			
	(22) Line 2 Topcoat B, clearcoat application	Body	38,100	115'L x 17'W x 15'H	Downdraft, removable grates, dyna tubes			
	(23) Line 2 repair, repair paint application	Body/parts	758	130'L x 17'W x 15'H	Downdraft, removable grates, dyna tubes			

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
Honda (Marysville) (cont'd)	(24) Line 2 small touch-up, lacquer touch-up	Interior parts	50	32'L x 17'W x 8'H	Downdraft, removable grates, dry booth			
	(25) Line 2 Wax 1, inner wax application	Interior parts	135 for booths 25 + 26	100'L x 17'W x 12'H	Downdraft, removable grates, dry booth			
	(26) Line 2 Wax 2, wax application	Under floor parts		66'L x 19'W x 17'H	Downdraft, removable grates, dry booth			
	(27) Bumperline primer, primer fascia application	Bumper	7,448 to 7,840	42'L x 17'W x 12'H	Downdraft, removable grates, waterwash floors			
	(28) Bumperline topcoat, basecoat fascia application	Bumper	7,448 to 7,840	34'L x 17'W x 12'H	Downdraft, removable grates, waterwash floors			
	(29) Bumperline clearcoat, clearcoat fascia application	Bumper	7,448 to 7,840	34'L x 17'W x 12'H	Downdraft, removable grates, waterwash floors			
	(30) POPA primer, Conductive fascia application	Bumper	16,000 to 16,995	65'L x 21'W x 12'H	Downdraft, removable grates, waterwash walls			
	(31) POPA clearcoat, clearcoat fascia application	Bumper	16,000 to 16,995	46'L x 21'W x 12'H	Downdraft, removable grates, waterwash walls			
	(32) POPA topcoat, basecoat application	Bumper	16,000 to 16,995	50'L x 21'W x 12'H	Downdraft, removable grates, waterwash walls			
Annual use of solvents for all booths						SP 20D Mineral spirits Xylene (Honda wash)	3,960 440 180,000	17 1 653
						All solvents	184,400	671

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
Nissan	(1) topcoat application	Car, cab, bed	350'L x 16.5'W x 13.5'H	Downdraft, removable grates, flooded sheet eliminators				
	(2) topcoat application	Car, cab, bed	350'L x 16.5'W x 13.5'H	Downdraft, removable grates, flooded sheet eliminators				
	(3) primer and antichip application	Car, cab, bed	350'L x 16.5'W x 13.5'H	Downdraft, removable grates, flooded sheet eliminators				
	(4) Repair	Car, cab, bed	350'L x 16.5'W x 13.5'H	Downdraft, removable grates, flooded sheet eliminators				
	(5) Fuel tank coating application	Fuel tanks	16'L x 16'W x 10'H	Sidedraft, concrete floor, N/A				
	(6) Fascia painting	Fascias	94'L x 24'W x 10'H	Downdraft, removable grates N/A				
Annual solvent usage for all booths						32577R Purge GS/C (purge solvent) 33396N wash solvent P3 SAF-T-Clean 113™	0 41,714 220	0 146 0
						All solvents	41,934	146
Subaru-Isuzu	(1) Topcoat, topcoat application	Entire body	78,000*10	315'L x 20'W x 37'H (13'H)	Downdraft, removable grates, waterwash	Purge thinner	1,464	5.0
	(2) Topcoat, topcoat application	Entire body	51,000*10	315'L x 20'W x 37'H (13'H)	Downdraft, removable grates, waterwash	Purge thinner	1,464	5.0
	(3) Two-tone repair (topcoat)	Entire body	1,200	191'L x 20'W x 37'H (13'H)	Downdraft, removable grates, waterwash	Purge thinner	1,464	5.0
	(4) Surfacer, prime coat & antichip application	Entire body	45,300	236'L x 20'W x 34'H (13'H)	Downdraft, removable grates, waterwash	Purge thinner	1,464	5 0

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
Subaru-Isuzu (cont'd)	(5) Black & wax, black-out & inner wax application	Entire body	7,800	96'L x 32'W x 26'H (13'H)	Downdraft, dry filter, removable grates	Purge thinner	1,464	5.0
	(6) Bumper, topcoat application	Entire body	4,200	99'L x 17'W x 28'H (10'H)	Downdraft, removable grates, waterwash	Purge thinner	1,464	5.0
	(7) Wax booth, under floor wax & acid-rain-proof coat application	Entire body	38,900	94'L x 18'W x 30'H (11'H)	Downdraft, removable grates, waterwash	Purge thinner	1,464	5.0
Annual use of solvents for all booths						Purge thinner	10,250	35
Toyota	(3407) Antichip, antichip application	Car body	16,750	60'L x 16.5'W x 12.5'H	Downdraft, removable grates, waterwash venturi			
	(3408) Underbody, antichip application to uderbody	Car body	32,050	126'L x 33'W x 17'H	Downdraft, removable grates, dry filter			
	(3411) (2) Primer/interior, primer application, innercoat application, black-out	Car body	93,750	280'L x 20'W x 13'H	Downdraft, removable grates, waterwash venturi			
	(3415) Touch-up, primer application	Car body	145	39'L x 16'W x 12.5'H	Downdraft, removable grates, side venturi			
	(3417) Topcoat A, topcoat & clear coat application	Car body	101,400	280'L x 20'W x 13'H	Downdraft, removable grates, waterwash venturi			
	(3418) Topcoat B, topcoat & clearcoat application	Car body	101,400	280'L x 20'W x 13'H	Downdraft, removable grates, waterwash venturi			

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
Toyota (cont'd)	(3419) Topcoat C, manual application of topcoat & clear-coat	Car body	101,400	190'L x 20'W x 13'H	Downdraft, removable grates, waterwash dynatube			
	(3424) Underbody/Black-out, manual application of black-out to body & manual wax application	Car body	11,950	59'L x 16.5'W x 12'H	Downdraft, removable grates, side venturi			
	(3426) Interior wax, touch-up application of black-out to underbody	Car body	6,700	98'L x 16.5'W x 12'H	Downdraft, removable grates, waterwash venturi			
	(3431) Exterior, engine, underbody wax, manual application of wax to engine & wheels, automatic application of wax to body	Car body	51,650	60'L x 16.5'W x 11'H	Downdraft, removable grates, waterwash venturi			
	(3311) Wax application, manual application of wax to body	Car body	789	30'L x 18'W x 10.5'H	Downdraft, removable grates, waterwash sub-floor			
	(3432) Topcoat repair, manual repair application of topcoat to body	Car body	145	43'L x 20'W x 11'H	Downdraft, removable grates, sub-floor pond: side			

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
Toyota (cont'd)	(3605) Antichip, antichip application to fuel tank	Fuel tank	11,500	42'L x 20'W x 15'H	Ceiling dry filter exhaust, plant floor			
	(3231) (2) Adhesive coating, manual application of adhesive to interior plastic	Interior, plastic parts	6,700	8.5'L x 6.08'W x 9.75'H	Side venturi, water, water curtain			
	(3238) Fascia primer, manual application of adhesion promotor and primer	Bumper	13,400	46'L x 13'W x 15'H	Downdraft, removable grates, waterwash venturi			
	(3241) Topcoat A, manual application (A)	Bumper	13,400	138'L x 11'W x 11.5'H	Downdraft, removable grates, waterwash walls			
	(3241) Topcoat B, manual and robotic application (B) of topcoat	Bumper	13,400	118'L x 16'W x 15'H	Downdraft, removable grates, waterwash venturi			
	(3244) (2) Molded plastic painting, manual application of lacquer to interior plastics	Interior plastic parts	6,700	8'L x 8'W x 8'H	Side venturi, water, water curtain			
	(8325) Adhesive coating, manual application of adhesive coat to interior	Interior plastic parts	6,700	8.5'L x 6.08'W x 9.75'H	Side venturi, removable grates, waterwash venturi			
	(EK-1002) Engine prime, application of black-out to engine	Engine blocks	5,000	9'L x 8'W x 8'H	Dry filter booth, concrete with plastic			

TABLE A-2. (continued)

Manufacturing company	(Booth No.), name, process performed inside the booth	Product painted	Total surface area painted, ft^2/shift	Booth dimensions	Booth characteristics	Cleaning solvent (brand name)	Quantity of solvent used in 1991, gal	VOC emissions from booth cleaning, tons/yr
Annual use of solvents for booths 3311 + 3431						Mineral spirits	213	0.7
Annual use of solvents for booths 3411 + 3417 + 3418 + 3419						Purge thinner	171,723	630
Annual solvent usage for booth Nos. 3238 + 3241A&B + 3244						Purge thinner	42,930	158
Annual solvent usage for booth Nos. 3407 + 3408 + 3415 + 3424 + 3426 + 3432						Purge thinner	38,300	127
Annual solvent usage for all booths						Parco Stripper	27,000	7
						AX-400	1,822	7
						Yumage ST-210	432	1
						Purge Thinner	251,323	922
						Mineral Spirits	800	3
						Thompson's STP	912	0
						All solvents	282,289	940

*1 Includes tack-off and demask areas.
*2 Stoneguard is applied to panels, and the surface area on which it is applied is unaccounted for.
*3 50 percent of the solvent is collected for disposal.
*4 This is the emissions reported by the plant. Because of unresolved discrepancies in the reported information, the accuracy of this value is uncertain.
*5 Approximately 10 percent of topcoat application.
*6 Approximately 10 percent of all painted surfaces.
*7 Assumes no spent solvent is collected.
*8 Usage discontinued in the middle of 1991.
*9 Used for cleaning track-out.
*10 10 percent of surface area painted is reconditioning work.

APPENDIX B

FACILITY PROFILES

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APPENDIX B.
FACILITY PROFILES

This appendix summarizes data from 15 plants that responded to an EPA request for information. Included are the number of spray booths and their use, the types of paint and cleaning solvents used, the cleaning practices for each booth component, the total usage of booth cleaning and purge solvents, resulting VOC emissions, and the spent solvent disposal practices. All data were derived from responses to the EPA's Section 114 information request, except where additional references are noted.[1-15]

Chapter 5 describes how the plants were asked to report the total VOC emissions from solvents used for booth cleaning and to use the UOS approach to present solvent usage, waste, and emissions from industrial or multiple booths. This appendix compares the emissions from both procedures and identifies any unresolved discrepancies between them.

B.1 AUTOALLIANCE ASSEMBLY PLANT (AAP) FLAT ROCK, MICHIGAN[1]

B.1.1 Spray Booths

The AAP has 16 (main-color split) booths. In these booths, both automotive bodies and plastic parts are painted. For painting automotive bodies, two booths are used for applying basecoat and clearcoat; one booth is used for applying PVC underbody coating; one booth is used for applying stoneguard coating; one booth is used for applying primer surfacer; one booth is used for applying two-tone paint; and one booth is used for blackout. For painting plastic parts, three booths are used to apply basecoat and clearcoat to small parts, and six booths are used for painting bumpers.

B.1.2 Paint Type

Four main types of paints are applied in the booths: (1) high-solids urethane antichip, (2) high-solids acrylic/melamine basecoat, (3) high-solids acrylic/melamine clearcoat, and (4) air dry water-based blackout paint.

B.1.3 Cleaning Practices

Both organic solvents and a variety of alternative cleaning practices are used to remove paint overspray in the booths. The cleaning practices for each of the booth components are as follows:

1. Walls. Visqueen™ covers are used on sections of the walls where paint overspray is heavy in the automotive painting booths. When necessary, the Visqueen™ covers are removed. Any residual paint remaining in these areas, and light paint buildup in other areas, is removed by applying organic solvent with a deck brush or rag and scrubbing; the walls are then wiped clean with a squeegee.

Walls in the booths used for painting plastic parts are covered with plastic sheeting (which is sprayed with fly catch). No organic solvents are used.

2. Windows. Heavy paint buildup in the automotive painting booths is removed with a razor blade. Any residual paint (and light overspray) is removed by applying organic solvent from a spray bottle, scrubbing with a rag, and using a squeegee for final cleaning. All overspray in the parts painting booths is removed by scraping with a razor blade.

3. Grates. High-pressure water blasting once a week is used to clean grates (in place) in the undercoating booth. Grates in the other automotive body painting booths are removed for onsite paint stripping using a fluidized, hot-sand stripping system. Grates in the parts painting booth are removed for paint cleaning via incineration.

4. Floors adjacent to booths are scraped.

5. Robots and related equipment are cleaned by manual scraping. Where possible, grease is applied to surfaces to prevent or reduce paint adhesion to the equipment.

6. Robotic and manual spray gun tips are cleaned at the end of the production shifts using sponges and brushes that are dipped into a solvent container. The used solvent is then transferred to a spent solvent storage tote that is taken to an offsite reclamation facility. The type of solvent used and the amount collected were not reported.

7. Fixtures are mostly covered with peelable coatings.

B.1.4 Use and Disposal of Booth Cleaners and Purge Solvents

Booth cleaners and organic solvents used for spray booth cleaning include Non-Meth 1200.7™ and Hasco-Wolverine EC™. Table B-1 shows the cleaning solvent usage based on the plant inventory and usage records. No spent booth cleaning solvent is collected.

TABLE B-1. SUMMARY OF SOLVENT USE AND VOC EMISSIONS FOR ALL SPRAY BOOTHS AT AAP[1]

Cleaning solvent	Annual total solvent usage, gal/yr	Annual solvent usage, gal/yr			VOC content, lb/gal	VOC emissions from booth cleaning, tons/yr
		Booth cleaning	Purging spray guns	Other		
Non-Meth 1200.7™	13,300	13,300	0	0	6.23	41.4
Hasco Wolverine EC™	3,200	1,300	0	1,900	5.72	3.7

1 ton = 2,000 lb.

Two solvents, Grow-8056™ and Grow-8019™, are used for purging spray guns used for painting automotive bodies and plastic parts, respectively. Both solvents are 100 percent VOC's. In 1991, 82 percent of Grow-8056™ and 26 percent of Grow-8019™ were collected and shipped to an offsite reclamation facility.[16]

B.1.5 VOC Emissions

The plant reported total VOC emissions from all sources in 1991 were 1,460 tons, of which 64.6 tons were from spray booth cleaning. However, the plant also developed three UOS's (one for the undercoating booth, one for the six automotive painting booths, and one for the nine parts painting booths) from which they reported emissions of only 43.9 tons/yr. (Correction of the VOC content of one solvent used in the calculations resulted in total VOC emissions of 45.1 tons/yr, as shown in Table B-1.) According to plant personnel, the UOS's do not include 20.8 tons/yr of VOC emissions that resulted from cleaning spray booth equipment outside the booth.[16] Plant personnel also indicated the use of organic solvent for cleaning each booth is not monitored and the amounts also could not be estimated.[16]

B.2 CHRYSLER, BELVIDERE ASSEMBLY PLANT (CBAP) BELVIDERE, ILLINOIS[2]

B.2.1 Spray Booths

The CBAP has four (main-color split) booths. Two are used for applying basecoat and clearcoat to car bodies; one is for topcoat repair, and one is for applying blackout to the underbody components.

B.2.2 Paint Type

Two main types of paints are applied in the booths: (1) high-solids acrylic/melamine topcoat (basecoat and clearcoat), and (2) air dry water-based blackout paint.

B.2.3 Cleaning Practices

The paint overspray in these booths is removed using both organic solvents and a combination of alternative cleaning practices, which eliminate or reduce the use of organic cleaning solvent. The cleaning practices are as follows:

1. Walls in the three topcoat application/repair booths are all glass and are coated with a water-washable, clear tacky coating. The walls are cleaned by spraying with large amounts of city tap water at approximately 40 psi. After cleaning, a new coat of tacky coating is applied. The walls in the blackout

booth are covered with polyethylene sheets that are replaced weekly. However, in the middle of the week the dried paint overspray is removed using a broom to sweep it down.

2. Windows in the blackout booth are cleaned using razor blade scrapers or putty knives (for stubborn spots).

3. Grates are removed nightly or weekly, depending upon the amount of paint overspray, and are replaced with clean grates. The dirty grates are stripped onsite using a hot alkaline stripper. Grates are not used in the blackout booth.

4. Floors adjacent to booths are mopped with booth cleaning solvent every night. The floor inside the blackout booth is covered with triple layers of a chipboard paper. During the week the floors are swept and the top layer of chipboards paper is peeled off, if necessary.

5. Robots and related equipment are manually wiped down, using rags and cleaning solvent (Sol 365). Some cabinetry (approximately 15 percent) is covered with aluminum foil sheeting, which is changed every night; other cabinetry (approximately 20 percent) is coated with the same tacky booth coating used for walls.

6. Robotic and manual-spray gun tips are manually wiped using solvent dampened rags during the production shifts, break times, and immediately at the end of the production shifts. Spray gun tips in the blackout booth are cleaned using rags moistened with naphtha.

7. Fixtures (center-track drive covers) are flooded with center-track stripper (Polystrip 3290™). After 15 to 20 minutes, the paint is loosened using flat-bladed scrapers. Then, the center-track drive is sprayed with low pressure water. This plant cannot use high-pressure water blasting because this method damages the wet pans, which are close to the grates.

B.2.4 Use and Disposal of Booth Cleaners and Purge Solvents

Booth cleaners and organic solvents used for spray booth cleaning include Sol-365™, Polystrip-3290™, and Sol-432™ (purge solvent). Table B-2 shows the cleaning solvent usage based on plant inventory records. From a total of 80,080 gallons (gal) of purge solvent used during the reported year, 3,800 gal (5 percent) were used for booth cleaning. No cleaning solvents, including those used for purging the paint guns and associated lines, are collected for recycling or reclamation.

TABLE B-2. SUMMARY OF SOLVENT USE AND VOC EMISSIONS FOR CBAP (ALL BOOTHS COMBINED)[2]

Cleaning solvent	Annual total solvent usage, gal/yr	Annual solvent usage, gal/yr			VOC content, lb/gal	VOC emissions from booth cleaning, tons/yr[a]
		Booth cleaning	Purging spray guns	Other		
Sol-365™	40,170	40,170	0	0	6.80	137
Polystrip-3290™	3,477	3,477	0	0	5.85	10
Sol-432™ (purge solvent)	80,080	3,800	76,280	0	7.10	13

[a]The spent solvent collected from booth cleaning and shipped offsite for disposal contained 7 tons of VOC's; the total weight of waste, including contaminants, was not reported.

Plant personnel estimated, based on engineering judgment, that 45 percent of the cleaning solvents were used for cleaning each topcoat application booth (a total of 90 percent for two booths), and 10 percent of the cleaning solvents were used for cleaning the repair booth.[17]

B.2.5 VOC Emissions

The plant reported that total VOC emissions from all sources in 1991 were 1,015 tons, of which 160 tons resulted from spray booth cleaning. The plant developed one UOS that included the three painting booths (no solvent was used in the blackout booth). As shown in Table B-2, the sum of emissions for all solvents in the UOS also equals 160 tons.

B.3 CHRYSLER, DODGE CITY ASSEMBLY PLANT (CDCAP) WARREN, MICHIGAN[3]

B.3.1 Spray Booths

The CDCAP has seven (main-color split) booths. Two booths are used for applying stoneguard, basecoat, and clearcoat. The uses of the other booths are as follows: one booth for applying two-tone paint, two booths for topcoat repair (the paint on car bodies is repaired after the low-bake stage in one booth and after the high-bake stage in the other booth); one booth for applying black paint (blackout) to the grills and wheel wells; and one booth for applying black paint to the chassis.

B.3.2 Paint Type

For main types of paints are applied in the booths: (1) high-solids urethane stoneguard, (2) high-solids acrylic/melamine basecoat, (3) high-solids acrylic/melamine clearcoat, and (4) air-dry, water-based blackout paint.

B.3.3 Cleaning Practices

The paint overspray in these booths is removed using both organic solvents and a combination of alternative cleaning practices, which eliminate or reduce the use of organic cleaning solvent. The cleaning practices are as follows:

1. Walls in most booths are cleaned using the following process: (1) spraying with cleaning solvent pumped from 55-gal drums, (2) manual scrubbing with brushes, and (3) rinsing with water. The walls are manually scraped in the blackout booths, once a month in one and as needed in the other.

2. Windows are cleaned in a similar manner as the walls, except in one blackout booth where the windows are sprayed with Windex™ or glass cleaner and wiped with paper towels.

3. Grates are removed once a week and are taken to the main-color spray booths. Grates are cleaned by being flipped and washed several times using high-pressure water blasting. When clean, the grates are coated with a non-VOC grate-coating. Finally, the coated grates are reinstalled.

4. Floors adjacent to booths are covered with one-sided fireproof, aluminum foil sheets. A new layer of aluminum foil sheeting is added or replaced, as necessary.

5. Robots and related equipment are manually wiped down using lint-free cloths and cleaning solvent. Some paint line hoses are wrapped in plastic wrap. Some equipment used for high-voltage electrostatic (HVES) paint application is covered with Tyvex™.

6. Robotic and manual spray gun tips are cleaned by wiping with a lint-free cloth and purge solvent. At the end of each production shift, some spray gun tips (bell cups) are cleaned using purge solvent and small paint brushes.

7. Fixtures (center-track drive covers) are coated with grease and are manually scraped on a rotating, weekly basis.

B.3.4 Use and Disposal of Booth Cleaners and Purge Solvents

Booth cleaners and organic solvents used for spray booth cleaning include AX-400 Paint Stripper™, purge solvent, glass cleaner, Windex™, and Rambo™. Table B-3 shows the cleaning solvent usage based on plant inventory records.

TABLE B-3. SUMMARY OF SOLVENT USE AND VOC EMISSIONS FOR CDCAP (ALL BOOTHS COMBINED)[3]

Cleaning solvent	Annual total solvent usage, gal/yr	Annual solvent usage, gal/yr			VOC content, lb/gal	VOC emissions from booth cleaning, tons/yr
		Booth cleaning	Purging spray guns	Other		
AX-400™	55,385	55,385	0	0	6.8	188
Purge solvent	140,849	10,034	130,815	0	7.12	36
Glass cleaner	447	5	0	0	1.56	0
Windex™	52	1	0	51	1.56	0
Rambo™	1,100	1,100	0	0	6.3	3.5

From a total of 140,849 gal of the purge solvent used during the reported year, 10,034 gal were used for booth cleaning. Plant personnel could not estimate the amount of solvent used for cleaning each booth. Spent booth cleaning solvents are not collected. However, in 1991, 130,815 gal of contaminated purge solvent from purging spray guns and lines were collected and sent to an offsite facility for reclamation (the VOC and contaminant concentration were not reported).

B.3.5 VOC Emissions

The plant reported that total VOC emissions from all sources in 1991 were 1,210 tons, of which 227.5 were from spray booth cleaning. The plant developed two UOS's: one for the booth used to apply blackout to the grills and wheel wells, and the second for all the other booths. As shown in Table B-3, the sum of the emissions for all solvents in the UOS's also equals 227.5 tons.

B.4 CHRYSLER, STERLING HEIGHTS ASSEMBLY PLANT (CSHAP) STERLING HEIGHTS, MICHIGAN[4]

B.4.1 Spray Booths

The CSHAP has six (main-color split) booths. Two booths are used for applying basecoat and clearcoat. The uses of the other booths are as follows: one booth for applying antichip and two-tone paint to car bodies, two booths for topcoat repair (the paint on car bodies is repaired after the low-bake stage in one booth and after the high-bake stage in the other booth), and one booth for blackout of the wheel wells.

B.4.2 Paint Type

Four main types of paints are applied in the booths: (1) high-solids urethane antichip, (2) high-solids acrylic/melamine basecoat, (3) high-solids acrylic/melamine clearcoat, and (4) air dry water-based blackout paint.

B.4.3 Cleaning Practices

The paint overspray in these booths is removed using both organic solvents and a combination of alternative cleaning practices, which eliminate or reduce the use of organic cleaning solvent. The cleaning practices are as follows:

1. Walls in four booths are covered with strippable coatings once a month. Between stripping, the walls are wiped as needed with a lint-free cloth that is dampened with solvent. The walls in the blackout booth are covered with a clear, heavy

plastic film. Dried paint is removed using a dry cloth or is brushed onto the floor where it is removed using a vacuum cleaner. In the low-bake repair booth, the walls remain uncovered and are cleaned nightly, using cloths dampened with solvent.

2. Windows are brushed with solvents, then cleaned with squeegees. In some areas, the windows are covered with plastic cling film. In the blackout booth, the windows are sprayed with a water-based cleaner, then cleaned by squeegees, and finally are wiped with dry paper towels.

3. Grates are removed once a week and cleaned by a contract cleaning company onsite, using high-pressure water blasting. In addition, grates are sprayed with a non-VOC removable coating. Grates in the blackout booth are also covered by roofing tar paper.

4. Floors adjacent to booths are partially masked (covered) with one-sided fireproof, aluminum foil sheeting or roofing tar paper. The exposed areas are mopped with floor cleaners.

5. Robots and related equipment are masked with aluminum foil sheeting or masking tape, wherever possible. Also, some manual cleaning is performed using lint-free cloths or brushes dampened with solvent.

6. Robotic and manual spray gun tips are cleaned at the end of each production shift and during breaks by wiping with a lint-free cloth dampened with solvent.

7. Fixtures (center-track drive covers, center rails, and I-beams) are coated with tacky coating and are manually scraped weekly with flat-bladed Berylco™ scrapers.

B.4.4 Use and Disposal of Booth Cleaners and Purge Solvents

Booth cleaners and organic solvents used for spray booth cleaning include MS-8464 (purge solvent), AX-400 Paint Stripper™, Shapkleen-2™, White Vincote™, and Nasco™ glass cleaner. Based on the inventory records, from a total of 82,712 gal of purge solvent used during the reported year, 4,136 gal (5 percent) were used for booth cleaning. Table B-4 shows the cleaning solvent usage based on the plant inventory records.

TABLE B-4. SUMMARY OF SOLVENT USE AND VOC EMISSIONS FOR CSHAP (ALL BOOTHS COMBINED)[4]

Cleaning solvent	Annual total solvent usage, gal/yr	Annual solvent usage, gal/yr			VOC content, lb/gal	VOC emissions from booth cleaning, tons/yr
		Booth cleaning	Purging spray guns	Other		
MS-8464™ (purge solvent)	82,712	4,136	78,576	0	6.96	14.4
AX-400™	19,140	19,140	0	0	6.90	66
Shapkleen-2™	1,920	1,920	0	0	3.60	3.5
White Vincote™	385	385	0	0	8.40	1.6
Nasco™ glass cleaner	150	75	0	75	1.56	0

The spent cleaning solvents from booth cleaning are not collected. However, a portion of the purge solvent used for purging the automatic and manual paint spray equipment (before the paint color change) is collected and reclaimed by an offsite facility. According to the plant, the reclamation facility reported collecting 54,773 gal of contaminated purge solvent in 1991. They also reported the average composition of the waste was 8.97 weight percent solids and 0.597 weight percent water.

B.4.5 VOC Emissions

The plant reported that total VOC emissions from all sources in 1991 were 586 tons, of which 85.6 tons were from spray booth cleaning. The plant developed three UOS's: one for the blackout booth, one for the topcoat repair after the low-bake stage, and one for the other four booths. The sum of the emissions for all solvents in the UOS's also equals 85.6 tons, and the results are shown in Table B-4. Plant personnel indicated that the use of organic solvent for cleaning each booth is not monitored, and the amount of solvent used for cleaning each booth could not be estimated.[18]

B.5 FORD, CHICAGO ASSEMBLY PLANT (FCAP) CHICAGO, ILLINOIS[5]

B.5.1 Spray Booths

The FCAP has seven booths. One is used for applying primer/guidecoat; two are used for applying basecoat and clearcoat; one is used for topcoat repair of the two-tone paint color (was not used in 1991); one is used for applying flange primer/black paint (blackout); one is used for repairing topcoat on the wheels; and one is used for applying transit coating on some areas on car bodies (e.g., hoods, roofs, etc.).

B.5.2 Paint Type

Three main types of paints are applied in the booths: (1) urethane antichip and nick guard primer, stoneguard, and flange primer/black paint; (2) high-solids acrylic/melamine primer/guidecoat, basecoat, clearcoat, and solid colors; and (3) water-based transit coating.

B.5.3 Cleaning Practices

The paint overspray in these booths is removed using both organic solvents and a combination of alternative cleaning practices, which eliminate or reduce the use of organic cleaning solvent. Daily cleaning is performed for the topcoat, primer, and two-tone repair booths. The other three booths are cleaned once a week. The cleaning practices are as follows:

1. Walls in the primer and topcoat booths are cleaned using low VOC cleaners and abrasive pads as needed. In the other booths, the walls are cleaned or are painted with latex paint as needed.

2. Windows are cleaned using low VOC cleaners and abrasive pads, as needed.

3. Grates are removed on a rotational basis, and are placed in a tank of hot caustic solution to be soaked.

4. Floors adjacent to booths are covered with tar paper (which is changed weekly) or soapy water saturated carpeting.

5. Robots and related equipment are both sprayed with purge solvent four (4) times per day and manually wiped.

6. Robotic and manual spray gun tips (turbobell cups) are placed in an ultrasonic cleaner twice a day.

7. Fixtures are cleaned in the same manner as the walls.

B.5.4 Use and Disposal of Booth Cleaners and Purge Solvents

Booth cleaners and organic solvents used for spray booth cleaning include Gage 31295 (AAD 803)™, Product Sol 50-8-3™, Product Sol 777™, and Peerless 813™ floor cleaner. Approximately 42 percent of the purge solvent was used for booth cleaning.[19] No waste booth cleaning solvent was collected; all of the spent solvent from purging the spray guns and lines was reportedly collected (but the composition of the collected waste was not reported).

B.5.5 VOC Emissions

The plant reported total VOC emissions from all sources in 1991 were 1,009 tons, but did not report the total VOC emissions from spray booth cleaning. Plant personnel developed one UOS that included all of the booths in which solvents were used. They also reported the plantwide usage of each solvent for spray booth cleaning and indicated no waste was collected. Thus, plantwide VOC emissions from spray booth cleaning were calculated. The total was 347 tons/yr, as shown in Table B-5.

B.6 FORD, DEARBORN ASSEMBLY PLANT (FDAP) DEARBORN, MICHIGAN[6]

B.6.1 Spray Booths

The FDAP has five booths. One is used for applying primer and antichip; one is used for applying basecoat and clearcoat; one is used for topcoat repair; one is used for final repair, and one is used for fascia painting.

B.6.2 Paint Type

Three main types of paints are applied: (1) one-component urethane antichip, (2) acrylic enamel basecoat and clearcoat, and (3) modified-polyester colored primer for interior and exterior.

B.6.3 Cleaning Practices

The paint overspray in these booths is cleaned using both organic solvents and a combination of alternative cleaning practices, which eliminate or reduce the use of organic cleaning

TABLE B-5. SUMMARY OF SOLVENT USE AND VOC EMISSIONS (ALL BOOTHS COMBINED)[5]

Cleaning solvent	Annual total solvent usage, gal/yr	Annual solvent usage, gal/yr			VOC content, lb/gal	VOC emissions from booth cleaning, tons/yr
		Booth cleaning	Purging spray guns	Other		
Gage 31295 (AAD 803)™ (purge solvent)	203,000	85,000	77,140	40,860	7.15	304
Product Sol 50-8-3™ (hose cleaner)	10,560	10,560	0	0	7.30	38.5
Product Sol 777™ (floor & wall cleaner)	2,292	2,292	0	0	3.34	3.8
Peerless 813™ (floor carpet mask)	1,650	1,650	0	0	0.42	0.3

solvent. Cleaning is performed daily. The cleaning practices are as follows:

1. Walls in different booths are cleaned using various practices. In most booths, walls are masked with a tacky coating. Accumulated paint and costing are removed with high-pressure water blasting. A low VOC and caustic cleaner may also be applied with the water. Tacky coating is then reapplied. In the final repair and fascia painting booths, the amount of paint overspray is light, and the walls are spot cleaned as needed.

2. Windows in the primer and topcoat booths are cleaned using high-pressure water blasting, followed by window cleaner and wiping. The window cleaner is also sprayed and wiped on the windows in the front fascia painting booth. Other booths do not have windows.

3. Grates in booths where paint overspray is extensive are cleaned in two steps. First, the grates are cleaned using high-pressure water blasting. For additional cleaning, the grates are placed and are soaked in a tank of hot caustic solution. For cleaning the grates in other booths, only the hot caustic bath is used.

4. Floors adjacent to booths are mopped with xylene.

5. Robots and related equipment (cabinets) are manually wiped with xylene, except in the front fascia booth, where the robots are covered with Tyvex™ covers.

6. Robotic and manual spray gun tips are manually wiped with xylene.

7. Fixtures, none.

B.6.4 Use and Disposal of Booth Cleaners and Purge Solvents

Xylene is the only solvent used for spray booth cleaning. As Table B-6 shows, from a total of 40,651 gal of xylene used, 5,278 gal were used for booth cleaning, based on the plant inventory and usage records. The percentage used in each booth is unknown. Information on the amount used for purging was not provided. Twenty-five percent of the cleaning solvent used for booth cleaning was collected for waste disposal (the total amount of waste, including contaminants, was not reported).

TABLE B-6. SUMMARY OF SOLVENT USE AND VOC EMISSIONS (ALL BOOTHS COMBINED)[6]

Cleaning solvent	Annual total solvent usage, gal/yr	Annual solvent usage, gal/yr			VOC content, lb/gal	VOC emissions from booth cleaning, tons/yr
		Booth cleaning	Purging spray guns	Other		
Xylene	40,651	5,278[a]	unknown	unknown	7.20	14

[a]According to the plant, contaminated solvent collected for offsite waste disposal contained 1,320 gal of solvent; the total waste, including contaminants, was not reported.

B.6.5 VOC Emissions

The FDAP reported total VOC emissions from all sources in 1991 were 292 tons, of which 14 tons were from spray booth cleaning. The plant developed one UOS that encompassed all spray booths. The xylene emissions for the UOS were also 14 tons, as shown in Table B-6.

B.7 FORD, TWIN CITIES ASSEMBLY PLANT (FTCAP) SAINT PAUL, MINNESOTA[7]

B.7.1 Spray Booths

The FTCAP has seven spray booths. One (Main Enamel booth) is used for applying topcoat (basecoat and clearcoat); one is used for applying two-tone basecoat, clearcoat, and repairing/accenting topcoat; one is used for applying antichip and primer; one is used for polishing and minor touchup; one is used for final repair; and one is used for applying wax coat. One booth has been used for frame touchup, but it has not been used since 1989.

B.7.2 Paint Type

Paints applied in the Main Enamel and Tu-tone booths include high-solids acrylic melamine basecoat, clearcoat, and solid colors. For repairing topcoat, chrome- and lead-free acrylic enamel paints are used.

B.7.3 Cleaning Practices

Paint overspray in these booths is removed using both organic solvents and a combination of alternative cleaning practices, which eliminate or reduce the use of organic cleaning solvent. The cleaning practices are as follows:

1. Walls in the topcoat and antichip/primer booths are all made of glass. These walls and those in the final repair booth are cleaned in three steps: (1) solvent is sprayed on the walls; (2) paint overspray is loosened manually with sponges, and (3) squeegees are used to remove paint and solvent. In the booth used for polishing, the walls are first vacuumed and then cleaned with razor blades and Windex™ glass cleaner. The walls in the transit coat booth are covered with plastic sheeting, which is changed as needed.

2. Windows in the polishing booth are cleaned manually using razor blades and Windex™ glass cleaner. The repair, touchup, and wax booths have no windows.

3. Grates in topcoat and antichip/primer booths are cleaned once a week, with high-pressure water blasting. All grates are removed once a year and placed in heat cleaning ovens.

4. Floors adjacent to booths either are covered with disposable tar paper or are mopped with solvents and alkaline floor cleaners.

5. Robots and related equipment are covered with washable nylon covers, which are removed and washed with solvent, and then reinstalled. The exposed areas of robots are manually wiped four (4) times per day with sponges moistened with solvents.

6. Robotic and manual spray gun tips are cleaned differently. The tip of the automatic guns are removed and are soaked in a solvent bath; they are cleaned manually with hand brushes. The manual spray guns are cleaned hourly in the gun cleaning station (located inside or outside the booths).

7. Fixtures are cleaned using a variety of practices. Paint line hoses and snap-ons are cleaned inside the booth, using portable part cleaners. Hooks and skids are cleaned in heat cleaning ovens. Exhaust tunnels, blowers and stacks are cleaned once a year with high-pressure water blasting.

B.7.4 Use and Disposal of Booth Cleaners and Purge Solvents

Table B-7 lists the organic solvents that were used for booth cleaning in 1991. Some of these solvents were also used for other cleaning, including purging of spray guns. The amounts used were based on the plant inventory and usage records. Plant personnel estimated 15,180 gal (20 percent) of the total purge solvent were used for booth cleaning, and the other 60,720 gal were used for purging the paint spray guns and associated lines.[20]

The waste solvent resulting from booth cleaning is sent offsite for reclamation or for use as fuel blend. Except for spent purge solvent, the spent solvents are not segregated. Approximately (based on the inventory records) 60,720 gal (80 percent) of purge solvent were collected, of which 7,590 gal were estimated to result from the purge solvent used for booth

TABLE B-7. SUMMARY OF SOLVENT USE AND VOC EMISSIONS (ALL BOOTHS COMBINED)[7]

Cleaning solvent	Annual total solvent usage, gal/yr	Annual solvent usage, gal/yr			VOC content, lb/gal	VOC emissions from booth cleaning, tons/yr
		Booth cleaning	Purging spray guns	Other		
CN-31295™ (purge solvent)	75,900	15,180[a]	60,720	0	7.34	27.9
Ethylene glycol monobutyl ether	935	935	0	0	9.28	
Cellosolve acetate	50	50	0	0	8.10	
n-Butyl acetate	58	53	0	5	7.37	
Hi Sol 10™	10,171	1,914	0	8,257	7.30	
Toluene	15,297	9,896	0	5,401	7.25	
Xylene	62,146	51,798	0	10,358	7.25	
Hi Sol 15™	6,246	669	0	5,577	7.38	
Butyl cellosolve acetate	245	13	0	232	7.85	
Methyl amyl ketone	55	16	0	39	6.80	
Methyl ethyl ketone	326	298	0	28	6.71	
DTR-600™ (lacquer thinner)	43	43	0	0	6.57	
E-227™	4,015	4,015	0	0	7.40	
Tennant-658™ (floor cleaner)	950	950	0	0	2.20	
Product Sol-793™ (floor cleaner)	770	770	0	0	0.73	
Product Sol 39-11-11™	213	213	0	0	1.70	
AWR-5441™	660	660	0	0	5.63	
Zepride-E™ (oven cleaner)	1,100	1,100	0	0	9.01	
1394-Zepeer™	11	11	0	0	8.11	
S-90™ Oven Cleaner	110	110	0	0	8.84	
CN-71712™ (floor cleaner)	220	220	0	0	8.42	
DCT™ (sealer cleaner)	165	165	0	0	1.79	
CN-71585™ (line stripper)	3,960	3,960	0	0	7.50	
RK-5352™ (flushing resin)	5,000	5,000	0	0	2.52	
Windex™ glass cleaner	180	100	0	80	8.30	

[a]Approximately 7,590 gal of solvent in waste were collected and sent offsite for disposal (the total waste and contaminant level were not reported).

cleaning (the total waste and contaminant level were not reported).[20] The amount of other spent solvents collected was not reported.

B.7.5 VOC Emissions

The plant reported total VOC emissions from all sources in 1991 were 556 tons, of which 78 tons were from spray booth cleaning. The plant also developed spray booth UOS's (some for individual booths and others for combinations). The material balance reported for the UOS's also show total booth cleaning emissions were 78 tons. However, there are unresolved discrepancies between the reported solvent usage values and the inputs for the material balances. Further, since only the total amount of spent solvent that is collected for waste disposal is known, the VOC emissions from each solvent cannot be calculated.

B.8 GENERAL MOTORS, FORT WAYNE ASSEMBLY PLANT (GMFWAP) FORT WAYNE, INDIANA[8]

B.8.1 Spray Booths

The GMFWAP has 10 modular paint spray booths; each module includes two booths. These 20 booths are used for applying basecoat and clearcoat. The plant also has three other booths; one is used for applying antichip; one is used for final paint repair, and one is used for painting wheels.

B.8.2 Paint Type

Paints applied in the booths include: (1) urethane antichip, (2) high-solids enamel basecoat, (3) polyurethane clearcoat, and (4) high solids enamel paint for wheels.

B.8.3 Cleaning Practices

The paint overspray in these booths is removed using both organic solvents and a combination of alternative cleaning practices, which eliminate or reduce the use of organic cleaning solvent. The cleaning practices are as follows:

1. Walls in modules 1 to 10 were cleaned once a week in three steps: (1) washing with high-pressure water, (2) spraying with cleaning solvent (as needed) and scrubbing with brushes, and (3) rinsing with high-pressure water. Walls in the antichip

booth were cleaned twice a week using high-pressure hot water; no solvent was used. Walls in the final repair and wheel painting booths were cleaned once a week with high-pressure steam; no solvent was used. After cleaning, walls in booths 1 to 10 and the wheel painting booth were recoated with a tacky coating.

2. Windows were cleaned using the same procedure that was used for the walls, except for the use of a tacky coating.

3. Grates were cleaned using the same procedures used for the walls, including the use of a tacky coating in all booths.

4. Floors in the booths were cleaned either with high-pressure water or high pressure steam. Solvent was used if necessary. After cleaning in booths 1 to 10, the floors were recoated with a tacky coating. Floors adjacent to booths were mopped nightly with a water-based cleaner.

5. Robots and related equipment were covered with protective covers, wherever possible. Uncovered areas were wiped with isopropyl alcohol. Spray guns were sent offsite monthly for chemical cleaning.

6. Robotic and manual spray gun tips were cleaned at the end of the production shifts by wiping with rags soaked in purge solvent.

7. Fixtures (center-track drive covers) were cleaned using high-pressure water.

B.8.4 <u>Use and Disposal of Booth Cleaners and Purge Solvents</u>

Booth cleaners and cleaning solvents used for spray booth cleaning include Atlantis Booth Stripper™, Golden Star Stainless Steel Cleaner™, isopropyl alcohol, Wonder Strip Floor Cleaner™, and Grow 6518™ (purge solvent). Table B-8 shows the cleaning solvent usage based on the plant inventory records. During 1991, 83,880 gal of the purge solvent were used. A total of 3,640 gal of the purge solvent was used for booth cleaning. Some of the purge solvent used to purge spray guns was recovered and reclaimed by an offsite facility. No booth cleaning solvent was collected.

TABLE B-8. SUMMARY OF SOLVENT USE AND VOC EMISSIONS (ALL BOOTHS COMBINED)[8]

Cleaning solvent	Annual total solvent usage, gal/yr	Annual solvent usage, gal/yr			VOC content, lb/gal	VOC emissions from booth cleaning, tons/yr
		Booth cleaning	Purging spray guns	Other		
Atlantis Booth Stripper™	43,230	43,230	0	0	7.14	154
Golden Star Stainless Steel Cleaner™	16	16	0	0	0	0
Isopropyl alcohol	2,695	200	0	2,495	6.50	1
Wonder Strip Floor Cleaner™	6,900	6,000	0	900	8.50	25
Grow 6518™ (purge solvent	83,880	3,640	80,240	0	6.90	13

B.8.5 VOC Emissions

For 1991, the total VOC emissions reported for the plant are 1,052 tons, of which 193 tons (18 percent) were from spray booth cleaning. The GMFWAP developed four spray booth UOS's: one that encompassed all 10 modules and one each for the other three booths. Plant personnel also reported average daily usage rates for each solvent in each UOS (rather than the usage per cleaning). As noted above, no spent solvent was collected from booth cleaning. Thus, as shown in Table B-8, emissions from booth cleaning equals the solvent usage.

B.9 GENERAL MOTORS, MORAINE ASSEMBLY PLANT (GMMAP) MORAINE, OHIO[9]

B.9.1 Spray Booths

The GMMAP has 12 (main-color split) spray booths. Two are for applying antichip; three are for applying topcoat (basecoat and clearcoat); one is for applying two-tone paint color; one is for applying deadener; two are for applying black paint to fuel tanks; one is used for topcoat paint repair, and two are for final repair.

B.9.2 Paint Type

Paints applied in the booths include (1) one-component urethane antichip, (2) high-solids acrylic enamel topcoat, (3) acrylic sealer deadener, (4) one-component urethane/polyester primer, and (5) black vinyl sealer for the chassis.

B.9.3 Cleaning Practices

The paint overspray in these booths is removed using both organic solvents and a combination of alternative cleaning practices, which eliminate or reduce the use of organic cleaning solvent. Light cleaning is performed once a day; deep cleaning is performed once a week, and super cleaning is performed once a year. The cleaning practices are as follows:

1. Walls are sprayed with TEXO LP1582™ that is washed down with water whenever needed--normally twice a week.

2. Windows are cleaned using the same procedure that is used for the walls; the only additional step is the use of squeegees for removing the excess water. In some (maybe all) booths, window cleaning is wall cleaning because the booths have glass walls.

3. Grates are cleaned with TEXO LP1582™ stripper during the light cleaning (touchups). During deep cleaning (on weekends), the grates and conveyors are cleaned using high-pressure water blasting.

4. Floors adjacent to booths are not included in the information provided by plant personnel.

5. Robots and related equipment (turbobells) are cleaned four times per shift by spraying purge solvent and isopropyl alcohol, and then wiping with rags.

6. Robotic and manual spray gun tips are cleaned four times per shift by spraying purge solvent and wiping with rags.

7. Fixtures (conveyors) are cleaned with high-pressure water blasting.

B.9.4 Use and Disposal of Booth Cleaners and Purge Solvents

The organic solvents used for spray booth cleaning include TEXO LP868™, TEXO LP1582™, TEXO LP856™, isopropyl alcohol, xylene, and reconstituted purge solvent. The plant used inventory records to determine the total usage of each solvent. As shown in Table B-9, reconstituted purge solvent and TEXO LP1582™ accounted for the bulk of the solvent used for booth cleaning. However, the amount of spent solvent collected was not reported (and there was no indication that any spent solvent was collected). The plant also did not report the amounts used for purging spray guns or other cleaning.

TABLE B-9. SUMMARY OF SOLVENT USE AND VOC EMISSIONS (ALL BOOTHS COMBINED)[9]

Cleaning solvent	Annual total solvent usage, gal/yr	Annual solvent usage, gal/yr			VOC content, lb/gal	VOC emissions from booth cleaning, tons/yr
		Booth cleaning	Purging spray guns	Other		
TEXO LP868™	4,400	N/A	N/A	N/A	2.40	b
TEXO LP1582™	31,704	31,704	0	0	7.09	112[a]
TEXO LP856™	880	N/A	0	N/A	9.1	b
Isopropyl alcohol	4,649	N/A	N/A	N/A	6.58	b
Xylene	57,071	7,205	N/A	N/A	7.20	26[a]
Reconstituted purge solvent	573,935	150,608	N/A	N/A	6.89	519[a]

N/A = not available.
[a]Assumes no waste was collected.
[b]VOC emissions cannot be calculated because annual solvent usage is unavailable.

B.9.5 VOC Emissions

Total VOC emissions in 1991 from all sources at the plant were reported to be 1,398 tons. Reported emissions from cleaning spray booths were either 139 or 750 tons, depending on which information in the response is to be believed. Estimates based on other data suggest the actual emissions were closer to the high value. Assuming no spent solvent was collected from booth cleaning, VOC emissions were at least 657 tons. The emissions could have been as high as 681 tons. This increase could have occurred if the three solvents (for which the amount used in booth cleaning was unknown) were included. Clarifications were requested from but not provided by the plant.

The plant developed several UOS's (some for individual booths and one for a combination) but did not provide the data needed in the material balances.

B.10 GENERAL MOTORS, OKLAHOMA CITY ASSEMBLY PLANT (GMOKAP) OKLAHOMA CITY, OKLAHOMA[10]

B.10.1 Spray Booths

The GMOKAP has seven (main-color split) spray booths. One is used for applying (1) antichip, (2) primer surfacer, (3) basecoat to the cowl and the trunk interior, and (4) semigloss black paint to the header (at windows) and the center post; two are used for applying basecoat and clearcoat; one is used for paint repair (but was not used in 1991); one is used for painting bumpers; one is used for painting the steering column; and one is used for final paint repair.

B.10.2 Paint Type

Paints applied in the booths include: (1) melamine/ formaldehyde antichip and semigloss black paint, (2) high-solids melamine/ formaldehyde primer surfacer and clearcoat, (3) acrylic melamine/ formaldehyde basecoat and brown-out enamel, and (4) polyester/polysiloxane melamine/formaldehyde primer (gray spotting primer).

B.10.3 Cleaning Practices

The paint overspray in these booths is removed using both organic solvents and a combination of alternative cleaning practices, which eliminate or reduce the use of organic cleaning solvent. The cleaning practices are as follows:

1. Walls are sprayed with a water soluble coating that is cleaned using high-pressure water whenever needed, normally twice a week.

2. Windows are cleaned using the same procedure that is used for the walls. The windows in the bell zone are manually wiped with stripper/purge thinner.

3. Grates are cleaned using high-pressure water blasting, where possible. In booths where water blasting cannot be used, the grates are covered with a grate coating material, and the grates are cleaned by removal and incineration.

4. Floors adjacent to booths are mopped nightly with IMS Thinstrip-F™.

5. Robots and related equipment are protected from overspray or cleaned using three methods: (1) cabinets are covered with plastic sheets, (2) areas that are not easily accessible to wiping are sprayed with paint stripper, and (3) turbobells and areas in the bell zone are manually wiped with purge solvent.

6. Robotic and manual spray gun tips are cleaned at the end of the production shifts either by soaking in the purge solvent inside a closed container or by manually mixing using the purge solvent.

7. Fixtures (car body carriers, conveyor return covers, spray hoses, hose racks, and booth access doors) are cleaned using different methods. The car body carriers are cleaned in a separate area using high-pressure water. The other fixtures are either sprayed or wiped manually with purge solvent.

B.10.4 Use and Disposal of Booth Cleaners and Purge Solvents

Booth cleaners and solvents used for spray booth cleaning include Grow 6518 and 5601™ (purge solvent), Polystrip 3450™, LP1582™, Texo 1664, Zepride™, and IMS Thinstrip-F™. Table B-10 shows the cleaning solvent usage based on the plant inventory records. In 1991, from a total of 144,800 gal of the purge solvent (virgin and reconstituted) used, 45,796 gal were used for booth cleaning and 99,004 gal were used for purging the paint lines and paint spray guns.

In 1991, 90,900 gal of the purge solvent were sent to an offsite facility for reclamation. An additional 11,700 gal of

TABLE B-10. SUMMARY OF SOLVENT USE AND VOC EMISSIONS (ALL BOOTHS COMBINED)[10]

Cleaning solvent	Annual total solvent usage, gal/yr	Annual solvent usage, gal/yr			VOC content, lb/gal	VOC emissions from booth cleaning, tons/yr
		Booth cleaning	Purging spray guns	Other		
Grow 6518 and 5601™ (purge solvent)	144,800	45,796[a]	99,004	0	6.9	138
LP1582™ and Texo 1664	42,000	42,000[a]	0	0	7.0	88.2
Polystrip 3450™	4,500	4,500[a]	0	0	7.5	13.5
IMS Thinstrip-F™	5,600	2,800[a]	0	2,800	7.5	8.4
Zepride™	3,200	2,600[a]	0	600	2.43	2.5

[a]The amount of waste solvent from booth cleaning sent offsite for use as fuel supplement: 5,857 gal Grow 6518 and 5601™, 900 gal of Polystrip 3450™, 16,800 of LP1582™ and Texo 1664, 520 gal Zepride™, and 560 gal of IMS Thinstrip-F™.

purge solvent were sent offsite for use as a fuel supplement; plant personnel estimate that 5,857 gal of this solvent were from booth cleaning. In addition to the purge solvent, approximately 40 percent of the LP1582™ and Texo 1664™ (16,900 gal) and 20 percent of the other three solvents (1,980 gal from booth cleaning) also were sent offsite for use as a fuel supplement.[21,22]

B.10.5 VOC Emissions

For 1991, the total VOC emissions reported for the plant were 1,196 tons, of which 257 tons (21 percent) were from spray booth cleaning. The plant also developed UOS's for single and multiple spray booths. However, they provided only purge solvent usage and waste data for the UOS's. Plantwide usage and waste data were provided for each of the booth cleaning solvents, and the difference was used to estimate plantwide emissions. As shown in Table B-10, the resulting VOC emissions were 251 tons (the plant erroneously used a high VOC content for one solvent to obtain total emissions of 257 tons).

B.11 HONDA, EAST LIBERTY ASSEMBLY PLANT (HELAP) EAST LIBERTY, OHIO[11]

B.11.1 Spray Booths

The HELAP has two paint lines that include a number of spray booths. The uses of the spray booths are similar to booths at HMAP.

B.11.2 Paint Type

Paints and coatings applied in the spray booths include: (1) waterborne acrylic enamel and lacquer basecoat, (2) acrylic enamel and lacquer clearcoat, (3) baking polyester primer surfacer, (4) lacquer for repairing and touchups, (5) air dry PVC sealer, and (6) various waxes, deadeners, and sealers.

B.11.3 Cleaning Practices

Paint overspray in these booths is removed using both organic solvents and a combination of alternative cleaning practices, which eliminate or reduce the use of organic cleaning solvent. The cleaning practices are as follows:

1. Walls in different booths are cleaned using various practices; generally, the practices are (1) covering the walls with plastic sheeting, secured by 2-inch masking tape; (2) wiping with either dry rags or with rags dampened with water, alcohol, xylene, or mineral spirits (different cleaning solvents are used for walls in different booths) that are dispensed from squeeze bottles; and (3) spraying the walls with Citrosolv™ (a solvent degreaser) using garden sprayers, then, after a while (time is needed for paint to react to Citrosolv™), using a rag to wipe the walls.

2. Windows in different booths are cleaned using various practices: (1) wiping with dry rags; (2) wiping with rags moistened with alcohol, window cleaner, or alcohol and a window cleaner; (3) wiping with rags soaked with xylene that is followed by lightly spraying the windows with window cleaner, which is wiped with clean rags; (4) wiping with rags moistened with deionized water that is followed by cleaning with squeegees; wiping with rags moistened with xylene, which is provided in

squeeze bottles, followed by cleaning with squeegees; (5) using mineral spirits and a window cleaner; and (6) spraying the windows with Citrosolv™ which is provided in 12-ounce (oz) bottles.

3. Grates are generally cleaned using high-pressure water blasting; however, some aspects of the grate cleaning vary in different booths. The variation is possibly the result of several factors such as the type of paint, the amount of paint overspray accumulated, the type of grates, booth design, etc. These variations are (1) the cleaning frequency, which ranges either from 1 week to 3 months, or as needed; (2) the pressure of water applied to the grates that ranges from a few hundred psi (using garden hoses to spray water) to either 3,000 psi or 10,000 psi; and (3) whether the grates are cleaned in place, or are removed and sent to a designated booth (the blackout booth) or a designated area in the plant for cleaning. In the later case, the grates are returned to the booths after cleaning is performed.

4. Floors adjacent to booths are covered with plastic sheeting (12 millimeter [mm] thick), which is changed weekly. Spot cleaning is performed using mineral spirits and rags.

5. Robots and related equipment are covered with protective covers wherever possible. Robots are cleaned by manual wiping with either dry rags or rags dampened with xylene, deionized water, or alcohol.

6. Robotic and manual spray gun tips are cleaned at the end of the production shifts by wiping with rags soaked in various liquids. Xylene, Citrosolv™, or alcohol are used in most booths. Deionized water is used in the basecoat repair booth.

7. Fixtures are cleaned with dry rags. Jigs are sent offsite for cleaning by incineration. Conveyors are covered with plastic.

B.11.4 Use and Disposal of Organic Booth Cleaners and Purge Solvents

Table B-11 lists all of the booth cleaning solvents used at the plant. It also includes estimates from paint shop personnel of the amount of each solvent used for spray gun purging/line flushing or other uses.[23] In 1991, 59,840 gal of the purge solvent were used for purging the spray guns and lines.

No cleaning solvents used for booth cleaning were collected. However, reportedly 99 percent of the purge solvent used for purging the spray guns (before paint color change) and paint lines was collected and shipped to an offsite facility for reclamation or to be used as fuel blend.

B.11.5 VOC Emissions

For 1991, the total amount of VOC emissions reported for the plant was 775 tons, of which 113 tons (15 percent) resulted from spray booth cleaning. The HELAP developed four incomplete spray booth UOS's for only five of the spray booths at the plant. The emissions shown in Table B-11 are based on clarifications of the original response.[23]

B.12 HONDA, MARYSVILLE ASSEMBLY PLANT (HMAP) MARYSVILLE, OHIO[12]

B.12.1 Spray Booths

The HMAP has 32 spray booths in two paint lines. The uses of the spray booths are as follows: one booth is for final repairs; one booth is for applying acid rain wax; one booth is for applying black wax; five booths are for final touchup; two booths are for applying sealer; two booths are for applying deadener and polyvinyl chloride (PVC) undercoating; two booths are for applying primer surfacer and antichip; two booths are for applying basecoat; two booths are for applying clearcoat; two booths are for repairing the topcoat; one booth is for applying two-tone paint; one booth is for small touchups; four booths are for applying waxes; and six booths are used for painting bumpers.

TABLE B-11. SUMMARY OF SOLVENT USE AND VOC EMISSIONS FOR HELAP (ALL BOOTHS COMBINED)[11]

Cleaning solvent	Annual total solvent usage[a], gal/yr	Annual solvent usage, gal/yr			VOC content, lb/gal	VOC emissions from booth cleaning, tons/yr
		Booth cleaning	Purging spray guns	Other		
Xylene	131,631	26,771	59,840	45,020	7.26	97.2
Isopropyl alcohol	8,809	4,666	200	3,943	6.57	15.3
TE-86254	1,837	0	323	1,514	7.34	0
TE-8190	1,615	0	99	1,516	7.34	0
T-9171	385	0	399	36	7.05	0
T-9153	1,065	0	397	668	7.31	0
Ethyl acetate	236	0	100	136	7.52	0
Butyl cellosolve	1,065	200	865	0	7.51	0.75
SC-100	2,128	0	284	1,844	7.40	0
SC-150	2,082	0	238	1,844	7.3	0
T-9182	220	0	220	0	7.27	0
RKF-93539	393	0	393	0	3.0	0
3608-S	1,564	0	680	884	6.61	0
Mineral spirits	220	70	0	150	6.71	0.2
Citrosolv™	3,294	100	0	3,194	6.51	0.3

[a]The annual quantity used in the Paint Shop Department.

B.12.2 Paint Type

Paints and coatings applied in the booths include: (1) acrylic enamel basecoat and clearcoat, (2) polyester/ melamine primer surfacer, (3) lacquer for touchups, (4) air dry PVC sealer, and (5) various waxes, deadeners, and sealers. The paint applied to bumpers (fascia painting) includes two-component urethane primer, basecoat, and clearcoat.

B.12.3 Cleaning Practices

The paint overspray in these booths is removed using both organic solvents and a combination of alternative cleaning practices, which eliminate or reduce the use of organic cleaning solvent. The cleaning practices are as follows:

1. Walls in different booths are cleaned using different practices; generally, the practices are (1) using peelable coatings and (2) wiping with either dry rags or with rags dampened with solvent dispensed from a squeeze bottle. These two practices may be used independently or together, depending upon the booth. Plastic sheeting and white paper with wax on one side are also used on walls in some booths.

2. Windows are wiped with rags that have been sprayed with xylene from a squeeze bottle. The excess solvent is removed using squeegees.

3. Grates are cleaned once a week using high-pressure water blasting. The cleaning is either performed inside the booths (after covering the walls and windows) or the grates are removed and sent to a designated booth (e.g., the blackout booth); after cleaning, the grates are returned to the booths.

4. Floors adjacent to booths are covered with cardboard or black felt paper. Every night, the cardboard is either cleaned by scraping or it is replaced.

5. Robots and related equipment are covered with protective covers wherever possible. Some robots are cleaned by manual wiping with either dry rags or dampened rags (xylene from a squeeze bottle is sprayed onto rags). The electrostatic

equipment (RMES) also is cleaned with rags and solvent (the cleaning solvent is made available in a grounded metal bucket).

6. Robotic and manual spray gun tips are cleaned at the end of the production shifts by manually wiping with rags dampened with xylene (supplied in squeeze bottles) and with Scotch brite pads.

7. Fixtures are mostly covered with plastic. Masking tape and grease are used on conveyor parts.

B.12.4 Use and Disposal of Organic Booth Cleaners and Purge Solvents

Booth cleaners and organic solvents used for spray booth cleaning include SP20D™, Honda wash (purge solvent, 80 percent xylene), and mineral spirits. Table B-12 shows the cleaning solvent usage based on estimates made by paint shop personnel. Plant personnel indicated that records for using cleaning solvents are not kept because record-keeping for the use of cleaning solvents is not required by the State air permit.

TABLE B-12. SUMMARY OF SOLVENT USE AND VOC EMISSIONS FOR HMAP (ALL BOOTHS COMBINED)[12]

Cleaning solvent	Annual total solvent usage, gal/yr	Annual solvent usage, gal/yr			VOC content, lb/gal	VOC emissions from booth cleaning, tons/yr
		Booth cleaning	Purging spray guns	Other		
SP2OD™	NA[a]	3,960	0	≥3,960	8.74	17
Mineral spirits	NA[a]	440	0	≥2,200	6.33	1
Honda wash (xylene, purge solvent)	432,000	180,000	72,000	180,000	7.26	653

NA = Not available
[a]The annual quantity used for all processes was not reported; however, the annual quantity used for all types of cleaning was reported: SP20D™ = 7,920 gal, and mineral spirits = 2,640 gal.

Based on paint shop personnel estimates, from a total of 432,000 gal of purge solvent used during 1991, 180,000 gal were used for booth cleaning and 72,000 gal were used for purging the paint spray guns and associated lines and other equipment. Plant personnel indicated that the use of solvents for cleaning each booth is not monitored and the amount could not be estimated.[23]

No spent cleaning solvents from booth cleaning were collected. However, a portion of the purge solvent used for purging the paint spray guns and lines (prior to paint color change) was collected and sent offsite for reclamation use as fuel.

B.12.5 VOC Emissions

The plant reported total VOC emissions from all sources in 1991 were 2,956 tons. Initially, the plant reported 31 tons resulted from spray booth cleaning. However, the plant revised the amount of purge solvent used for booth cleaning, which changed the total emissions to 671 tons.[24]

The HMAP did not provide information on spray booth UOS's. However, plantwide emissions for each solvent were estimated to equal usage because no spent booth cleaning solvent was collected. Table B-12 provides information on the VOC emissions from booth cleaning.

B.13 NISSAN ASSEMBLY PLANT (NAP) SMYRNA, TENNESSEE[13]

B.13.1 Spray Booths

The NAP has six (main-color split) booths. One is used for applying antichip and primer; two are used for applying basecoat and clearcoat; one is used for topcoat repair; one is used for applying fuel tank coating to the fuel tanks; and one is used for painting plastic parts.

B.13.2 Paint Type

Paint applied in the booths include: (1) enamel solvent adhesion-promoter, (2) polyester primer, (3) enamel basecoat, (4) clearcoat, (5) St. shade (6) fuel tank coating, and (7) elastomeric enamel clearcoat.

B.13.3 Cleaning Practices

The paint overspray in these booths is removed using both organic solvents and a combination of alternative cleaning practices, which eliminate or reduce the use of organic cleaning solvent. The cleaning practices are as follows:

1. Walls in most booths are covered with peelable coatings. Once a month, paint overspray on the walls is scraped, and the walls are resprayed with peelable coating. In the fascia booth, walls are covered with stretch wrap and spot cleaned by wiping with a solvent-soaked rag. Walls in the fuel tank booth are coated with vaseline and then scraped clean.

2. Windows are cleaned with the wash solvent, which is applied using rags and brushes. Squeegees are used to remove excess materials and to clean the windows.

3. Grates are cleaned using high-pressure water-blasting mowers.

4. Floors adjacent to most booths are cleaned with low-VOC aqueous cleaners. Floors in the fascia booth are spot cleaned by wiping with a rag and alcohol; they are then sopped with window wash. Floors in the fuel tank booth are covered with tar paper and plastic that is replaced daily.

5. Robots and related equipment are covered with protective covers or plastic, wherever possible. Robot arms and hoses are cleaned with wash solvent. Bells and reciprocating equipment are cleaned with a solvent. Cabinets are cleaned with alcohol.

6. Robotic and manual spray gun tips in most booths are cleaned with solvent at the end of the production shifts. In the fuel tank booth, the tips are cleaned with water.

7. Fixtures are cleaned as follows: manual hoses are cleaned with solvent; and X-tree stands are wiped with lint-free rags and solvent.

B.13.4 <u>Use and Disposal of Booth Cleaners and Purge Solvents</u>

Booth cleaners and organic solvents used for spray booth cleaning include 32577R Purge GS/C (purge solvent), 33396N wash solvent, and P3 SAF-T-Clean 113™. Table B-13 shows the cleaning solvent usage based on the plant inventory and usage records. Purge solvent is used only for purging spray guns and related equipment; none is used for booth cleaning. Plant personnel estimated that 66.6 percent of the cleaning solvents is used in topcoat booths, and 33.3 percent is used in the primer booth.

TABLE B-13. SUMMARY OF SOLVENT USE AND VOC EMISSIONS FOR NAP (ALL BOOTHS COMBINED)[13]

Cleaning solvent	Annual total solvent usage, gal/yr	Annual solvent usage, gal/yr			VOC content, lb/gal	VOC emissions from booth cleaning, tons/yr
		Booth cleaning	Purging spray guns	Other		
32577R Purge GS/C (purge solvent)	167,356	0	167,356	0	7.0	0
33396N wash solvent	41,714	41,714	0	0	7.0	146
P3 SAF-T-Clean 113™	220	220	0	0	0	0

The spent cleaning solvents from booth cleaning were not collected. However, some of the purge solvent used for purging the paint spray guns and lines (before the paint color change) was collected for reclamation. An offsite facility reclaimed 30,000 gal of the purge solvent in 1991.[25]

B.13.5 VOC Emissions

For 1991, the total amount of VOC emissions reported for the plant was 1,297 tons, of which 146 tons (11 percent) resulted from spray booth cleaning. The NAP did not develop UOS's. Thus, plantwide VOC emissions from all booth cleaning solvents were calculated assuming emissions equal usage (146 tons), as shown in Table B-13.

B.14 SUBARU-ISUZU ASSEMBLY PLANT (SIAP) LAFAYETTE, INDIANA[14]

B.14.1 Spray Booths

The SIAP has a total of seven (main-color split) spray booths. Three booths are used for applying basecoat, clearcoat, and two-tone paint to car bodies. The uses of the other booths are as follows: one booth is for applying primer surfacer and antichip; one booth is for applying blackout and inner wax; one booth is for applying under-floor wax, NO_x rust, and acid-rain-proof coat; and one booth is for fascia painting, which includes applying adhesion promoter, basecoat, and clearcoat to bumpers.

B.14.2 Paint Type

Paints applied in the booths include: (1) melamine/acrylic basecoat, (2) acrylic/melamine clearcoat, (3) polyester/melamine surfacer, (4) polyester/polyurethane stoneguard, and (5) polyester/melamine antichip.

B.14.3 Cleaning Practices

The paint overspray in these booths is removed using both organic solvents and a combination of alternative cleaning practices, which eliminate or reduce the use of organic cleaning solvents. The cleaning practices are as follows:

1. Walls are masked by peelable coatings that are removed and replaced twice a month in some booths and once a month in other booths.

2. Windows in most booths are wiped by cloth rags moistened with solvent. In the two wax booths, windows are wiped with rags and non-VOC window cleaner.

3. Grates are removed and cleaned by water blasting at a designated area within the plant.

4. Floors adjacent to booths are covered with plastic sheets that are changed daily.

5. Robots and related equipment are covered with Tyvex™ robot covers that are replaced three times per week. In the under-floor wax booth, a rag with a small amount of solvent is also used.

6. Robotic and manual spray gun tips are cleaned at the end of the production shifts by manually dipping the tips in small solvent dip baths.

7. Fixtures are covered with Tyvex™ covers or plastic sheeting. Grease is applied to fixtures below the grating.

B.14.4 Use and Disposal of Booth Cleaners and Purge Solvents

The only organic solvent used for spray booth cleaning is the purge thinner, which is 100-percent VOC. Plant personnel indicated that the use of organic solvent for cleaning each booth is monitored; they estimated that usually 7 to 10 gal (on average) of the solvent are used to clean each booth daily.[26]

Based on the plant inventory records, from a total of 273,827 gal of the purge thinner used during the reported year, 10,250 gal were used for booth cleaning. No spent solvent from booth cleaning is collected.

In 1991, 15,931 gal of the purge solvent used for purging spray guns and paint lines were recovered onsite, using a mobile recycling unit. In addition, 204,691 gal of contaminated solvent (solvent plus paint) were sent offsite for use as fuel blend.[26]

B.14.5 VOC Emissions

For 1991, the total VOC emissions reported for the plant were 813 tons, of which 35 tons were from spray booth cleaning.

The SIAP did not provide information for spray booth UOS's. However, the plantwide cleaning solvent usage was used to confirm the reported VOC emissions of 35 tons, as shown in Table B-14.

TABLE B-14. SUMMARY OF SOLVENT USE AND VOC EMISSIONS FOR SIAP (ALL BOOTHS COMBINED)[14]

Cleaning solvent	Annual total solvent usage, gal/yr	Annual solvent usage, gal/yr			VOC content, lb/gal	VOC emissions from booth cleaning, tons/yr
		Booth cleaning	Purging spray guns	Other		
Purge thinner	273,827	10,250	253,077	10,500	6.88	35

B.15 TOYOTA ASSEMBLY PLANT (TAP) GEORGETOWN, KENTUCKY[15]

B.15.1 Spray Booths

The TAP has 22 (main-color split) booths. In these booths, both automotive bodies and plastic parts are painted. For painting automotive bodies, two booths are used for applying underbody paint and coatings; two booths are used for applying antichip; one booth is used for applying primer; three booths are used for applying basecoat and clearcoat; one booth is used for topcoat repair; one booth is used for touchup; three booths are used for applying waxes; and one booth is used for applying engine primer to the engine blocks. Five booths are used for painting interior plastic parts, and three booths are used for painting plastic bumpers.

B.15.2 Paint Type

Different types of paints are applied in the booths. The main paint systems are as follows: three types of antichip coatings (PVC plastisol, urethane resin, and PVC), polyester primer, acrylic sealer, polyester enamel for interior solid colors, acrylic melamine basecoat, polyester solid coat, acrylic melamine clearcoat, polyester-melamine plastic primer, urethane plastic clearcoat, and polyester melamine, acrylic, and acrylic lacquer blackout paint.

B.15.3 Cleaning Practices

The paint overspray in these booths is removed using both organic solvents and a combination of alternative cleaning practices, which eliminate or reduce the use of organic cleaning solvent. The cleaning practices are as follows:

1. Walls are protected from overspray or cleaned using different practices depending on the booth. The practices are: (1) manual scraping along with partial kraft paper coverage and wiping heavily coated areas with solvent, (2) wiping with rags and purge solvent, (3) the use of heavy-duty kraft paper and wiping with a rag and purge solvent, (4) masking with paper and tape, (5) using peelcoat and occasionally spraying purge solvent on areas with heavy paint overspray, and (6) high-pressure water blasting in wax booths.

2. Windows are wiped using non-VOC glass cleaners or purge solvent and rags. In booths used for applying waxes, windows are cleaned using high-pressure water.

3. Grates are cleaned onsite in a designated area in a hot caustic dip followed by rinsing with high-pressure water. In booths used for applying waxes, grates are soaked in a tank containing a caustic de-waxing agent.

4. Floors adjacent to booths are covered with kraft masking paper.

5. Robots and related equipment are covered with plastic protective covers, wherever possible. Foil is used to partially cover robots in one booth. Exposed areas on robots are wiped

with the purge solvent and rags. In booths used for applying waxes, automatic equipment is cleaned using high-pressure water and mineral spirits.

6. Robotic and manual spray gun tips are cleaned with the purge solvent.

7. Fixtures are wiped with rags and the purge solvent.

B.15.4 <u>Use and Disposal of Booth Cleaners and Purge Solvents</u>

Booth cleaners and organic solvents used for spray booth cleaning include Parco Stripper™ (caustic), AX-400 Paint Stripper™, Toyota Purge Blend™, mineral spirits, Thompson Glass Cleaner™, and Yumage ST-210™. Table B-15 presents the cleaning solvent usage based on the plant inventory and usage records. Also based on these records, from a total of 499,648 gal of the purge solvent used during the reported year, 251,323 gal (50 percent) were used for booth cleaning and 248,325 gal were used for purging the paint spray guns.[27] Plant personnel could not estimate the amount of solvent used for cleaning each booth.

TABLE B-15. SUMMARY OF SOLVENT USE AND VOC EMISSIONS AT TAP (ALL BOOTHS COMBINED)[15]

Cleaning solvent	Annual total solvent usage, gal/yr	Annual solvent usage, gal/yr			VOC content, lb/gal	VOC emissions from booth cleaning, tons/yr
		Booth cleaning	Purging spray guns	Other		
Parco Stripper™ (caustic)	29,000	27,000	0	2,000	0.52	7
AX-400 Paint Stripper™	1,822	1,822	0	0	7.67	7
Toyota Purge Blend™	499,648	251,323	248,325	0	7.34	922
Mineral spirits	1,000	800	0	200	6.57	3
Thompson Glass Cleaner™	912	912	0	0	0	0
Yumage ST-210™	432	432	0	0	3.38	1

No spent cleaning solvents from booth cleaning were collected. However, an offsite facility reclaimed 248,325 gal of the purge solvent used for purging the paint spraying and lines (prior to the paint color changes) in 1991; the total contaminated solvent collected and the contaminated level were not reported.

B.15.5 VOC Emissions

For 1991, the total VOC emissions reported for the plant were 2,219 tons, of which 940 tons (42 percent) resulted from spray booth cleaning.

The TAP developed five UOS's that each encompassed two or more of the booths in which cleaning solvent is used. They also reported the plantwide usage of each booth cleaning solvent. There are slight discrepancies between the usage and waste reported for the UOS's and the plantwide values. The VOC emissions from booth cleaning shown in Table B-15 are based on the reported plantwide usage with no spent solvent collection.

B.16 REFERENCES FOR APPENDIX B

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APPENDIX C

TERMS AND DEFINITIONS FOR SOLVENT CLEANING

APPENDIX C.

TERMS AND DEFINITIONS FOR SOLVENT CLEANING

This Appendix presents a glossary of terms and definitions used in this report.

Boundary

It is used to mark the limits for the material balance.

Cleaning activity

Physical removal of foreign material from substrate being cleaned. Includes actions such as wiping, brushing, flushing, or spraying.

Cleaning classification

For convenience, cleaning has been considered to have three main classifications: (1) cleaning of external surfaces, (2) cleaning of interior surfaces (i.e., containers), and (3) cleaning of removable parts.

Cleaning of external surfaces

Solvent is applied to the "external surface" being cleaned (as contrasted to the interior of tanks or pipes). Surfaces that fall within this classification include rollers in printing machines, wings of airplanes, floors, tables, and walls. The "cleaning activities" applied to the external surface may include mopping, brushing, or spraying and use "cleaning tools" such as rags, brushes, mops, or spraying equipment.

Cleaning of internal surfaces/containers

Solvent is applied to an interior surface for cleaning. Surfaces may include the inside of tanks/vessels, batch reactors, columns, heat exchangers, paint spray booths, and fuel tanks. The "cleaning activities" applied may include flushing, agitation, spraying, and mopping or brushing. Any combination of activities may be used, depending on the shape and size of the "unit operation" and on the type residue that is being removed.

Cleaning of parts

Solvent engulfs the entire surface of the item (part) as it is dipped in a container of solvent, or the part is cleaned above the container by a cleaning activity such as spraying or wiping. Equipment, the "unit operation," where this might take place, includes part washers, batch-loaded cold cleaners, ultrasonic cleaners, and spray gun washers.

Cleaning practices

A repeated or customary action that is specific to an industry. An example is nightly maintenance of a spray booth in an automobile assembly plant

Cleaning tool

An item used to aid cleaning, such as wiping rags, brushes, scrapers, or water jets.

Closed-loop recycling (in-process recycling)

Reuse or recirculation of a chemical material within the boundaries used to develop a material balance around a "unit operation system." A recovery or reclamation (R or R) unit operation may be within the boundaries selected for the primary unit operation system if it is:

1. Solely dedicated. The chemical is reused only for cleaning the primary unit operation.

2. Physically integrated. The R or R operation is connected to the primary unit operation by means of piping, so that it is not possible to perform the material balance around the primary unit operation system without including it.

Hazardous Air Pollutant (HAP)

Any of almost 200 substances identified as air toxics in Section 112 of the Clean Air Act Amendments of 1990.

In-process recycling

(See closed-loop recycling).

Line flushing

Line flushing is the procedure of completely cleaning out a large paint circulating system such as those found at auto assembly plants. The system includes the paint mix tanks and perhaps hundreds of feet of pipe or piping. This procedure is only necessary when a system is inadvertently contaminated or for a routine color change.

Although the system is essentially closed loop, some losses can occur during the flushing (i.e. through various vents, from transfer operations and from the paint mix tanks). In the information supplied to the Agency, automobile assembly plants with closed loop systems estimated a 10 percent loss from the line flushing operation, independent of the solvent used, but they provided no data or rationale to support the estimates.

Onsite recycling

An R or R unit operation located within the plant boundaries from which clean solvent is returned to a process other than that which generated the waste solvent. A material balance for the R or R unit operation (distillation, filtration, etc.) should be developed independently.

See "storage containers." (Emissions during cleanup of the R or R unit operation should not be overlooked when determining the long-term solvent efficiency of the unit.)

Offsite recycling

An R or R unit operation system located outside of the plant boundaries.

Pollution prevention

Practices or process changes that decrease or eliminate the creation of emissions (or wastes) at the source. Such prevention techniques include use of new materials, modification of equipment, and changes in work practices.

Product substitution

Replacement of any product or raw material intended for an intermediate or final use with another. This substitution is a source reduction activity if either the VOC emissions or the quantity of waste generated is reduced.

Protective covers

Shielding of materials used to blanket or enrap all or parts of a surface.

Purging

The process wherein individual paint applicators and portions of paint delivery lines are emptied of one color paint, cleaned, and filled with another. This is a common cleaning practice in the automobile assembly industry.

Reclaim

"Reclaim" means a material is processed or regenerated to recover a usable product. (See recycle).

Recovery or regeneration (R or R) unit operation

A device for purifying solvent that may use any of a variety of techniques, including extraction, distillation, filtration, adsorption, or absorption.

<u>Recycle</u>

"Recycled" means used, reused, or reclaimed (40 CFR 261.1(b)(7)). A material is "used or reused" if it is either employed as an ingredient (including its use as an intermediate) to make a product. For example, when solvent recovered by distillation is reused in the plant.

<u>Reuse</u>

See "used."

<u>Source reduction</u>

Any activity or treatment that reduces or eliminates the generation of VOC emissions (or waste), including product substitution or elimination and pollution prevention.

<u>Storage container</u>

Emissions from storage containers are to be included in a material balance.

<u>Treatment</u>

Destruction or degradation of waste using techniques such as combustion or neutralization to produce material that is less toxic and more environmentally benign. (See recycle).

<u>Unit operation (UO)</u>

An industrial operation, classified or grouped according to its function in an operating environment. Examples include distillation columns, paint mixing vessels (tanks), spray booths, parts cleaners and printing machines. A unit operation may consist of one or more items of equipment, e.g., both a reactor and a mixing vessel or several mixing vessels. There may be considerable variation in the type of unit operations from one industry to another. (See unit operation system.)

Unit operation system (UOS)

The ensemble of equipment around which a material balance is performed. A UOS includes all possible points/sources that could result in losses to the atmosphere as a result of its being cleaned, including losses during dispensing of solvent, losses from residual solvent on or in cleaning tools (such as rags), losses from solvent storage, etc. An item of equipment used for cleaning parts by definition is a unit operation, therefore, carry-out losses during removal of cleaned parts should be considered in a material balance.

Used (or reused)

A material is "used or reused" if it is employed as an ingredient (including use as an intermediate) in an industrial process to make a product (for example, in purifying a waste solvent, distillation bottoms from one column may be used as feedstock in another).

Volatile Organic Compounds (VOC)[1]

[NOTE: This definition may subsequently change. The Code of Federal Regulations (40 CFR 51.100[s]) will provide the current legal definition.] Any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions.

1. This includes any such organic compound other than the following, which have been determined to have negligible photochemical reactivity: methane; ethane; methylene chloride (dichloromethane); 1,1,1-trichloroethane (methyl chloroform); 1,1,1-trichloro-2,2,2-trifluoroethane (CFC-113); trichlorofluoromethane (CFC-11); dichlorodifluoromethane

(CFC-12); chlorodifluoromethane (CFC-22); trifluoromethane (FC-23); 1,2-dichloro 1,1,2,2-tetrafluoroethane (CFC-114); chloropentafluorethane (CFC-115); 1,1,1-trifluoro 2,2-dichloroethane (HCFC-123); 1,1,1,2-tetrafluoroethane (HFC-134a); 1,1-dichloro 1-fluoroethane (HCFC-141b); 1-chloro 1,1-difluoroethane (HCFC-142b); 2-chloro 1,1,1,2-tetrafluoroethane (HCFC-124); pentafluoroethane (HFC-125); 1,1,2,2-tetrafluoroethane (HFC-134); 1,1,1-trifluoroethane (HFC-143a); 1,1-difluoroethane (HFC-152a); and perfluorocarbon compounds which fall into these classes:

(a) Cyclic, branched, or linear, completely fluorinated alkanes;

(b) Cyclic, branched, or linear, completely with fluorinated ethers with no unsaturations;

(c) Cyclic, branched, or linear, completely fluorinated tertiary amines with no unsaturations; and

(d) Sulfur containing perfluorocarbons with no unsaturations and with sulfur bonds only to carbon and fluorine.

2. For purposes of determining compliance with emission limits, VOC will be measured by the test methods in the approved State implementation plan (SIP) or 40 CFR Part 60, Appendix A, as applicable. Where such a method also measures compounds with negligible photochemical reactivity, these negligibility-reactive compounds may be deducted from the reported VOC if the amount of such compounds is accurately quantified, and such exclusion is approved by the enforcement authority.

3. As a precondition to excluding these compounds as VOC or at any time thereafter, the enforcement authority may require an owner or operator to provide monitoring or testing methods and results demonstrating, to the satisfaction of the enforcement authority, the amount of negligibly-reactive compounds in the source's emissions.

4. For the purposes of Federal enforcement for a specific source, the EPA shall use the test method specified in the applicable EPA-approved SIP, in a permit issued pursuant to a

program approved or promulgated under Title V of the Act, or under 40 CFR Part 51, Subpart I or Appendix S, or under 40 CFR Parts 52 or 60. The EPA shall not be bound by any State determination as to appropriate methods for testing or monitoring negligibly-reactive compounds if such determination is not reflected in any of the above provisions.

Waste minimization

Means the reduction, to the extent feasible, of hazardous waste that is generated or subsequently treated, stored or disposed. It includes any source reduction or recycling activity undertaken by a generator that results in either (1) the reduction of total volume or quantity of hazardous waste, or both, so long as such reduction is consistent with the goal of minimizing present and future threats to human health and the environment. In order of preference there are: source reduction, recycling, and treatment.

Water Blasting

This term refers to cleaning practices that involve spraying high pressure water on a surface to remove contaminants.

Work practice

This term is reserved for specific human activities within industry that lead to a reduction in VOC emissions (or waste). The activities include increased operator training, management directives, segregation of the waste solvent, and practices that lead to a reduction in cleaning frequency. It does not include the use of specialized equipment, such as solvent dispensers.

REFERENCES FOR APPENDIX A

1. 40 CFR Part 51, Vol. 57, No. 22, February 3, 1992.

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16. ABSTRACT

Cleaning of automobile spray booths is a source of volatile organic compound (VOC) emissions. This study was conducted to obtain and evaluate information on: (1) the use of alternative cleaning practices within the industry that reduce or eliminate the use of organic cleaning solvents, (2) the current level of VOC emissions resulting from spray booth cleaning, and (3) the emission reductions achieved by implementing alternative cleaning practices. Information from 15 automobile assembly plants operated by eight companies was reviewed, evaluated, and summarized. Solvent use and alternative cleaning practices were identified for seven categories of booth components: walls, floors, grates, robots/equipment, spray equipment tips, windows, and fixtures. Annual (1991 base year) spray booth cleaning emissions reported by the 15 plants are presented. This document also explains procedures for estimating VOC emissions from spray booth cleaning based upon the Unit Operation System (UOS) concept.

The conclusions from this study are: (1) there is significant potential for VOC emissions reductions; (2) emissions and, thus, potential reductions range from a few tons to nearly 1,000 tons per year per plant; (3) typical emissions reductions achieved by specific alternatives are less than 20 tons/yr but can range up to nearly 200 tons/yr; and (4) elimination of solvent spraying, as a cleaning practice, holds the greatest potential for reducing emissions.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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